PATENT COOPERATION TREATY

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

From the INTERNATIONAL BUREAU

To:

Commissioner
US Department of Commerce
United States Patent and Trademark Office, PCT
2011 South Clark Place Room CP2/5C24
Arlington, VA 22202
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in its capacity as elected Office

Date of mailing (day/month/year) 20 February 2001 (20.02.01)	
International application No. PCT/SE00/01052	**Applicant's or agent's file reference** LH/Ru 43402
International filing date (day/month/year) 24 May 2000 (24.05.00)	**Priority date** (day/month/year) 10 June 1999 (10.06.99)
Applicant BOKSTRÖM, Monica et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International Preliminary Examining Authority on:

03 January 2001 (03.01.01)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was [ ] was not made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO **34, chemin des Colombettes** **1211 Geneva 20, Switzerland** Facsimile No.: (41-22) 740.14.35	Authorized officer R. E. Stoffel Telephone No.: (41-22) 338.83.38

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WORLD INTELLECTUAL PROI
International I

INTERNATIONAL APPLICATION PUBLISHED UNDE

(51) International Patent Classification 6 :
D21C 9/10, B01J 3/02, D21C 7/06

A1

(11) I WO 9605365A1

(43) International Publication Date: 22 February 1996 (22.02.96)

(21) International Application Number: PCT/US95/10391

(22) International Filing Date: 8 August 1995 (08.08.95)

(30) Priority Data:
08/288,845 11 August 1994 (11.08.94) US

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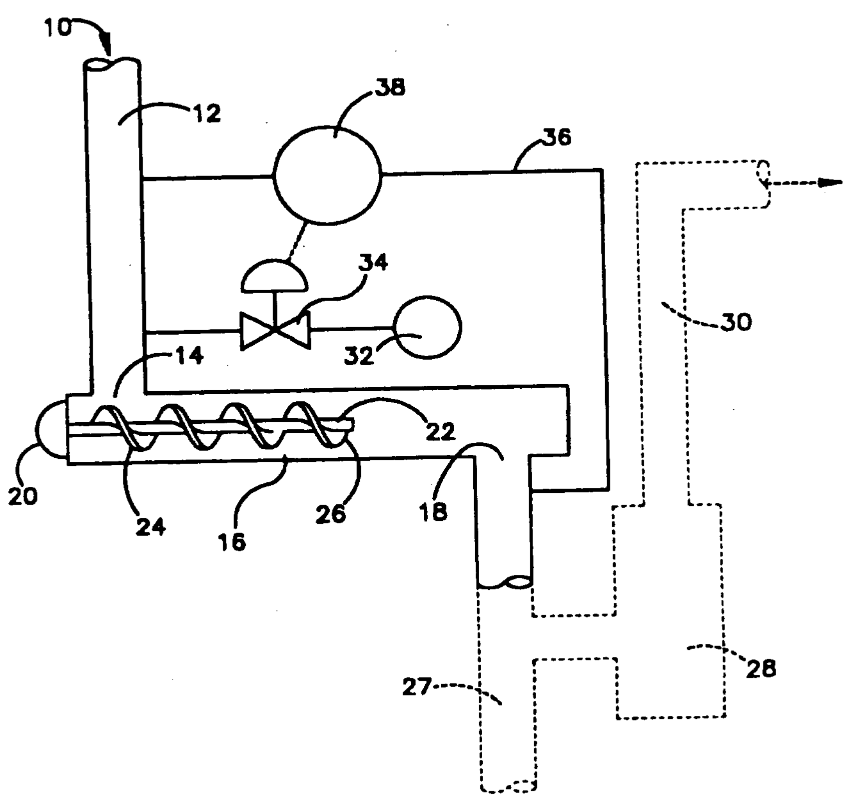
(81) Designated States: AT, CA, FI, JP, SE.

Published
With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: MEANS FOR GAS-SEALINGLY CONVEYING SHREDDED PULP

(57) Abstract

A wall passageway, having openings therein only at opposite, inlet (14) and outlet (18) ends thereof, has a shaft (22) journalled therein. The shaft carries a screw thereon for moving shredded pulp through the passageway. The screw (24) is foreshortened, having a length less than that of the passage way, and causes inlet-admitted pulp to form into a continuously moving pulp plug. The plug, albeit having some porosity, comprises a gas seal within the passageway, and inhibits any migration of downstream gas from escaping to the atmosphere via the passageway and the inlet (14) thereof. In addition, a source (32) of oxygen or such gas as is inert to any downstream process is controllingly admitted into the inlet (14) to maintain an upstream pressure equal to, or greater than any downstream process pressure to insure against release of downstream gas into the atmosphere.



LH43402

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MEANS FOR GAS-SEALINGLY CONVEYING SHREDDED PULP

BACKGROUND OF THE INVENTION

This invention pertains to wood pulp bleaching processes, such as those which employ gaseous bleaching reagents contacted with high consistency (i.e. twenty percent or more) fluffed pulp, and in particular to means for gas-sealingly conveying shredded pulp, in a pulp-handling process, to a downstream vessel or device.

Wood pulp bleaching with gaseous reagents, such as ozone and other high reaction rate gases, promises significant reduction of objectionable pulp mill effluents to streams and other bodies of water, as well as reduction of objectionable gaseous emissions. Elimination of chlorine compounds from the bleaching sequence promises great economic and ecological benefits. However, incorporation of these bleaching reagents can impose significant capital costs on the pulp mill due to the use of pulp transport devices which are expensive and generally require frequent maintenance.

In the use of a bed type reactor, for example, such as described in U.S. Patent No. 3,814,664, issued to Carlsmith, et al., a thick stock pump is required to feed the pulp to the fluffer while sealing the vessel pressure from the thickening device which generally operates under atmospheric pressure. In another method, described in U.S. Patents Nos. 5,181,989; 5,164,043; and 5,164,044 issued to Griggs, et al., and 5,174,861; 5,211,811; and 5,188,708 issued to White, et al., a screw feeding device is used to transport the pulp to the fluffer, again while sealing the vessel pressure from the thickening device which operates under atmospheric pressure.

SUMMARY OF THE INVENTION

It is a purpose of this invention to disclose an efficient and inexpensive means for gas-sealingly conveying shredded pulp, from a thickening device to a downstream vessel, without having to employ a thick stock pump, a screw feeder, or such other expensive and high-maintenance equipment.

Particularly, it is a purpose of this disclosure to define means for gas-sealingly conveying shredded pulp, comprising a pulp conveyor having a pulp inlet and a pulp outlet; wherein said conveyor has openings only at said inlet and said outlet; and conduit means in communication with said inlet for admitting shredded pulp into said inlet; and said conveyor comprises means for transforming inlet-admitted, shredded pulp into a substantially effective, translating, gas seal between said inlet and said outlet.

The aforesaid, and further purposes and features of this invention, will become apparent by reference to the following description, taken in conjunction with the accompanying figures.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a schematic diagram of a shredded pulp conveying means, according to an embodiment of the invention; and

Figure 2 is a diagram of an alternate embodiment of the pulp conveyor of Figure 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In gas phase bleaching of pulp, the pulp is first thickened to a high consistency, i.e., twenty percent or more, in a thickening device. By way of example, such a thickening device can be a twin roll press (not shown) which discharges the pulp to a breaker/shredder conveyor (not shown). Regardless of

from whence the shredded pulp is derived, the same is represented by the arrow 10, in Figure 1, as the source thereof. The sourced, shredded pulp is conducted to a conduit 12 which is in open communication with the inlet 14 of a pulp conveyor 16. The conveyor 16 has an outlet 18 at the end thereof which is opposite the inlet 14, and the inlet 14 and outlet 18 are the only openings in the conveyor 16. The conveyor is otherwise a walled passageway. Journalled in the conveyor 16, for rotation therein, by means of a motor 20, is a shaft 22 which carries thereon a screw 24. The screw 24 has a length which is less than that of the conveyor 16, one end of the screw 24 being in alignment with the inlet 14. The terminal end 26 of the screw 24, then, is distanced from the outlet 18. Shredded pulp is admitted into the inlet 14, from the conduit 12, for movement thereof along the conveyor 16 by the rotatable screw 24. As a consequence, the admitted pulp forms into a porous plug downstream of the screw 24. Typically, in a gas phase bleaching of pulp, downstream of the conveyor 16 would be a vessel having a gaseous reagent which may be toxic or otherwise objectionable. Consequently, it is important to insure that the relevant gas does not leak or insinuate itself through the conveyor 16 for release into the atmosphere. Under operating conditions, then, the screw 24 and conveyor 16-formed porous plug serves as the sealing medium. The continuously-admitted shredded pulp is caused to transform into a continuously moving plug, advancing toward the outlet 18, which inhibits a migration of the downstream gas in the opposite direction.

The outlet 18, optionally, can communicate with an immediate discharge conduit 27, shown only in phantom, for conduct therefrom to an ozone contactor. Too, depending upon the process requirements, the outlet can be in communication with a shredding or fluffing device 28 (shown only in phantom), if further shredding or fluffing of the pulp is required. Then, the pulp can be conducted, via a conduit 30 (shown only in phantom) to a

downstream reaction vessel.

As noted, under dynamic conditions of continuous plug transport through the conveyor 16, the continuously forming and moving plug will serve as the only required gas sealing between ends of the conveyor, and the inlet 14 and outlet 18. During system shutdown, however, when the advance of the plug is halted, it is possible that gas will weep through the halted plug and get released to the atmosphere. The invention comprehends means for addressing this matter. In order to maintain reliability of the gas sealing, the invention is enhanced by incorporating a control means whereby oxygen, or other suitable gas which is inert in the downstream process, is added in relatively small quantities to maintain a pressure somewhat higher in the feed to the sealing conveyor 16, as compared to the pressure downstream. As shown in Figure 1, a source 32 of oxygen, for instance, is communicated to the conduit 12, via a control valve 34. In this manner, a small quantity of gas passes through the porous plug to the downstream processing, it being arranged that the quantity and type of gas (oxygen or other) does not have a negative impact on the downstream ministrations. The functionality is provided by automatically controlling the pressure in the inlet 14 at or above the pressure under which the downstream process is operating. For example, the invention sets forth maintaining an upstream pressure of from one-tenth to five psig above the downstream process pressure. In the disclosed embodiment, this control is effected by bridging across the inlet 14 and outlet 18 with a pressure-sensing line 36 which has incorporated therein a differential pressure control 38, the latter being linked to the valve 34 for supervisory operation thereof.

sealing conveyor 16

Figure 2 shows an alternate embodiment of the pulp conveyor 16' in which the journalled shaft 22', which carries the screw 24 thereon, is journalled in the outlet end of the conveyor (as well as in the inlet end

thereof). In adjacency to the far or downstream end of the shaft 22' is provided a plurality of perpendicularly-disposed breaker bars 40. Bars 40 further break up the pulp, particularly the pulp plug, to accommodate the passage of the pulp through the outlet 18.

The invention advances the art, in that it allows for the replacement of a high cost, high maintenance, positive displacement feeder with a simple, inexpensive, conveyor-type screw 24. Further, it reduces the compaction forces to which the pulp is subjected in conventional feeding devices to a minimal amount of compaction in the porous plug. Those skilled in the art will recognize that the reduction or elimination of compacting forces will substantially improve the fluff quality obtained in downstream devices, and will thereby reduce the quantity of reactant gas required for the receiving process.

It is a teaching of this invention that it is possible to eliminate a high maintenance, high cost device in such system while providing for enhanced performance of the downstream fluffing and reaction system, thereby reducing the cost, and improving the system performance.

While I have described my invention in connection with specific embodiments thereof, it is to be clearly understood that this is done only by way of example, and not as a limitation of the invention as set forth in the purposes thereof and in the appended claims. Benefiting from my disclosure herein, others will find a plurality of procedures for conveying shredded pulp without unduly compacting the same before discharging the pulp to a downstream vessel or device, and conveyance of the pulp without permitting downsteam gaseous reagents, or the like, from passing through the conveyor 16 and venting upstream. In the first procedure, it is only required to design the conveyor 16 and the cooperating screw 24 to insure that the plug, which is

formed ahead of the screw 24, is of sufficient length that it adequately accomplishes the necessary gas sealing through the conveyor 16. Alternatively, the employment of the source 32 of pressurizing gas (oxygen, or such), and the line 36, control valve 34 and control 38 is deemed a useful expedient should it become necessary to prevent gas leakage through the conveyor 16 toward the inlet 14 at shut-down. If it is deemed warranted to use a shorter length conveyor 16 which will not provide for a pulp plug having a sufficient length to prevent gas leakage through the conveyor 16, the differential pressure can be employed as an integral part of the system. In this, of course the source 32 can provide a continuous, slightly elevated pressure at the inlet 14 all during system operation. Then, with shut-down, if it is necessary to raise the pressure at the inlet 14, the differential pressure arrangement is in place to accommodate for this. All of these operational methods are comprehended by this invention, and within the ambit of the appended claims.

What is claimed is:

1. A pulp conveyor comprising:

a housing having an inlet and an outlet, the housing being divided into at least two regions including a conveyor region and a gas seal region;

a screw type conveyor rotatably mounted within the conveyor region of the housing, the screw type conveyor forming a pulp plug at a discharge of the conveyor and discharging the pulp plug into the gas seal region of the housing; and

a moving pulp plug having a predetermined length such that the length of the pulp plug in the gas seal region forms a gas seal plug to prevent the flow of gas from the outlet to the inlet, the gas seal region of the housing being characterized by the absence of means for disrupting the pulp plug.

2. The pulp conveyor according to claim 1, wherein the gas seal region of the housing is in fluid communication with the outlet.

3. The pulp conveyor according to claim 1, wherein the housing is divided into three regions, the third region being a pulp plug breaking region, the pulp plug breaking region being in fluid communication with the gas seal region and the outlet; and further comprising:

a pulp breaker rotatably mounted within the pulp plug breaking region of the housing.

4. The pulp conveyor according to claim 1, wherein the housing has a first end and a second end, the screw type conveyor having a shaft journaled in the first and second end of the housing, the shaft extending through the gas seal region of the housing.

5. The pulp conveyor according to claim 1, further comprising:

a means for establishing a pressure between the housing inlet and the housing outlet.

6. A pulp conveyor comprising:

a housing having an inlet and an outlet, the housing being divided into at least two regions including a conveyor region and a gas seal region;

a formation means for forming a moving pulp plug, the formation means being in the conveyor region of the housing, the formation means including a screw type conveyor rotatably mounted within the conveyor region of the housing, the screw type conveyor forming a pulp plug at a discharge of the conveyor and discharging the pulp plug into the gas seal region of the housing; and

a conveyor means for conveying the moving pulp plug without disrupting the moving pulp plug a predetermined distance from the formation means towards the outlet, the moving pulp plug being located within the gas seal region, the conveyor means including the gas seal region of the housing being characterized by the absence of means for disrupting the pulp plug, the gas seal region having a predetermined length such that the length of the pulp plug in the gas seal region forms a gas seal plug to prevent the flow of gas from the outlet to the inlet.

7. The pulp conveyor according to claim 6, further comprising:

a means for establishing a pressure between the housing inlet and the housing outlet.

8. A method for conveying pulp in a housing having an inlet and an outlet, the housing being divided into at least two regions including a conveyor region and a gas seal region, a screw type conveyor being rotatably mounted in the

conveyor region of the housing, comprising the steps of:

supplying pulp to the conveyor;

rotating the conveyor forming a pulp plug at the discharge of the conveyor;

sealing the housing to prevent the flow of gas from the outlet to the inlet by moving the pulp plug without disrupting the pulp plug through the gas seal region of the housing a predetermined distance from the conveyor towards the outlet.

9. The method according to claim 8, further comprising the step of: establishing a pressure between the housing inlet and the housing outlet.

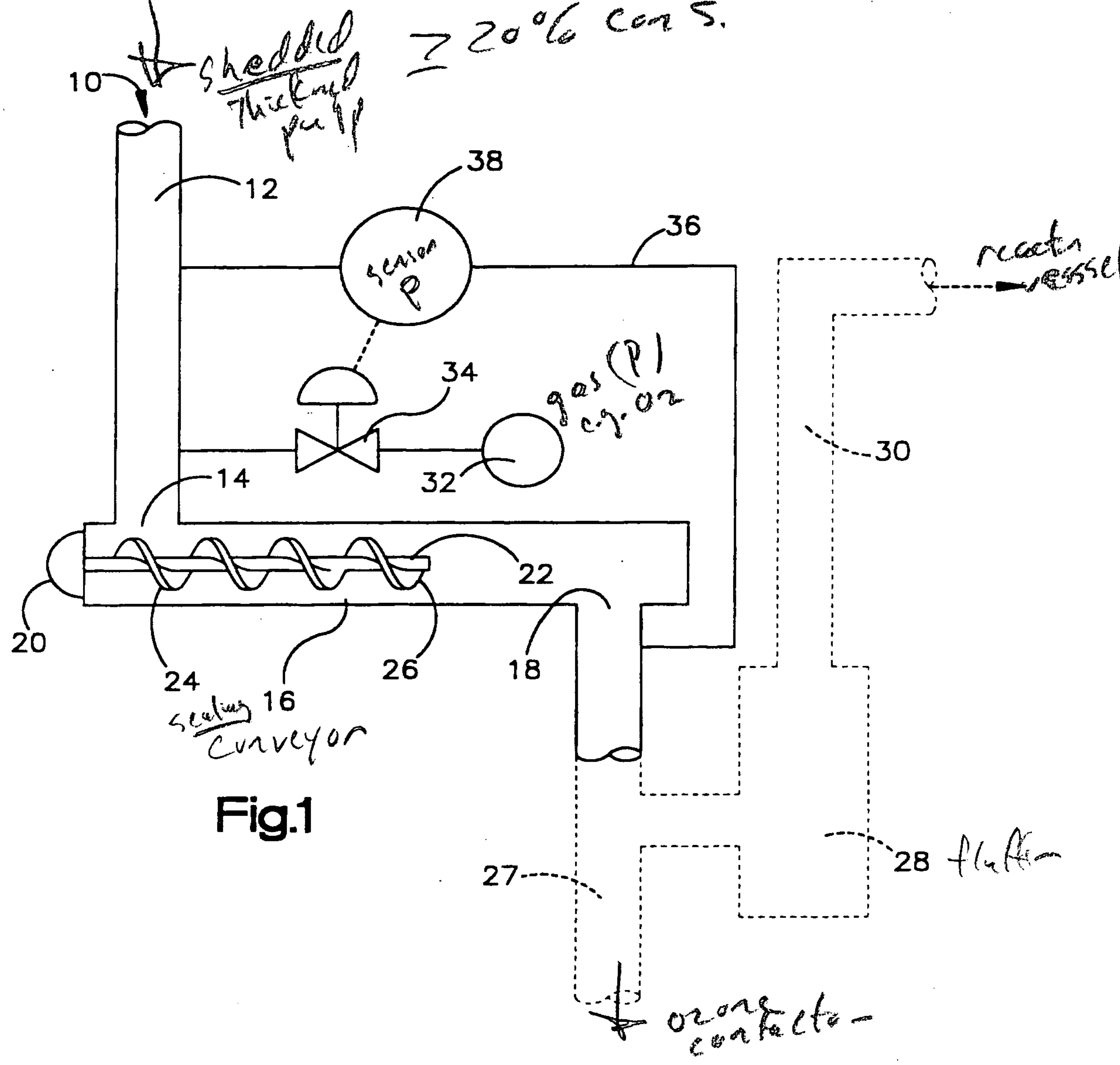
thick
shedded
Thickened
pulp
≥ 20% cons.
10
12
38
sensor
P
36
reactor
vessel
34
gas (P)
e.g. O2
30
32
14
22
20
24
16
sealing
conveyor
26
18
27
28 fluffer
ozone
contactor

Fig.1

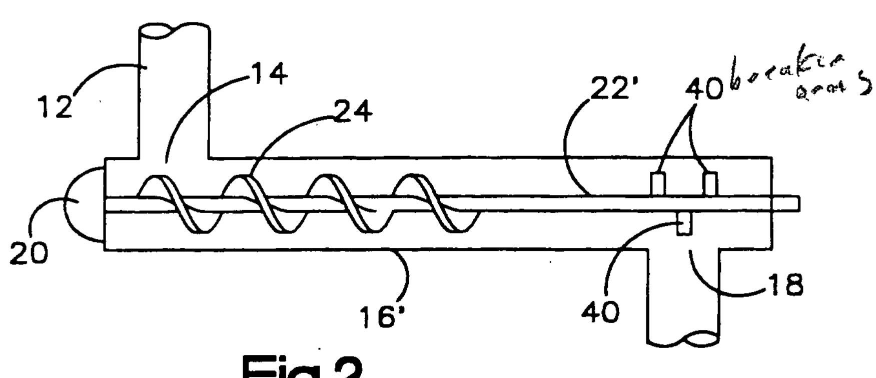
12
14
24
22'
40 breaker
arms
20
16'
40
18

Fig.2

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 95/10391

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 D21C9/10 B01J3/02 D21C7/06

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 D21C B01J

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	FR,A,2 378 125 (STAKE TECHNOLOGY LTD) 18 August 1978 see page 2, line 23 - page 3, line 2	1,2,6,8
Y		3,4

Y	FR,A,2 672 314 (INGERSOLL RAND CO) 7 August 1992 see page 8, line 1 - line 5; figure 1	3,4

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
11 January 1996	24.01.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Bernardo Noriega, F

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/US 95/10391

Patent document cited in search report	Publication date	Patent family member(s)		Publication date
FR-A-2378125	18-08-78	AU-B-	3269278	02-08-79
		BE-A-	863159	16-05-78
		CA-A-	1070537	29-01-80
		DE-A-	2714993	27-07-78
		GB-A-	1599092	30-09-81
		JP-A-	53111102	28-09-78
		SE-A-	7800730	25-07-78
FR-A-2672314	07-08-92	AT-A-	139491	15-06-95
		AU-B-	646267	17-02-94
		AU-B-	8044191	13-08-92
		CA-A-	2046717	07-08-92
		CN-A-	1063915	26-08-92
		DE-A-	4203131	13-08-92
		ES-A-	2050566	16-05-94
		IT-B-	1250690	21-04-95
		JP-A-	6057672	01-03-94
		SE-A-	9102209	07-08-92

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference LH/Ru 43402	**FOR FURTHER ACTION**	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/SE00/01052	International filing date *(day/month/year)* 24.05.2000	Priority date *(day/month/year)* 10.06.1999
International Patent Classification (IPC) or national classification and IPC7 D 21 C 9/153, D 21 C 7/06		
Applicant Valmet Fibertech AB et al		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 3 sheets, including this cover sheet.

   ☐ This report is also accompanied by ANNEXES, i.e., sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of ______ sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand 03.01.2001	Date of completion of this report 19.09.2001
Name and mailing address of the IPEA/SE Patent- och registreringsverket Box 5055 S-102 42 STOCKHOLM Telex 17978 PATOREG-S Facsimile No. 08-667 72 88	Authorized officer Marianne Bratsberg/ELY Telephone No. 08-782 25 00

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.
PCT/SE00/01052

I. Basis of the report

1. With regard to the **elements** of the international application:*

☒ the international application as originally filed

☐ the description:
pages ______, as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☐ the claims:
pages ______, as originally filed
pages ______, as amended (together with any statement) under article 19
pages ______, filed with the demand
pages ______, filed with the letter of ______

☐ the drawings:
pages ______, as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

☐ the sequence listing part of the description:
pages ______, as originally filed
pages ______, filed with the demand
pages ______, filed with the letter of ______

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.
These elements were available or furnished to this Authority in the following language ______ which is:

☐ the language of a translation furnished for the purposes of international search (under Rule 23.1(b)).
☐ the language of publication of the international application (under Rule 48.3(b)).
☐ the language of the translation furnished for the purposes of international preliminary examination (under Rules 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

☐ contained in the international application in written form.
☐ filed together with the international application in computer readable form.
☐ furnished subsequently to this Authority in written form.
☐ furnished subsequently to this Authority in computer readable form.
☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. ☐ The amendments have resulted in the cancellation of:
☐ the description, pages ______
☐ the claims, Nos. ______
☐ the drawings, sheet/fig ______

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed, as indicated in the Supplemental Box (Rule 70.2 (c)).**

* *Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are annexed to this report since they do not contain amendments (Rules 70.16 and 70.17).*

** *Any replacement sheet containing such amendments must be referred to under item I and annexed to this report.*

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No.

PCT/SE00/01052

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Claims	1-10	YES
	Claims		NO
Inventive step (IS)	Claims	1-10	YES
	Claims		NO
Industrial applicability (IA)	Claims	1-10	YES
	Claims		NO

2. Citations and explanations (Rule 70.7)

Cited documents:

D1. WO 9605365 A1

D2. US 4278496 A

The documents cited in the International Search Report represent background art.

The invention defined in claims 1-10 is not disclosed by any of these documents. None of the documents reveal a method and an apparatus for the treating of pulp in a closed shredding vessel prior to a bleaching step with ozone in a reaction vessel, in which shredding vessel, the gas pressure is kept higher than the gas pressure in the reaction vessel.

None of the cited documents give any indication towards the claimed invention and no relevant combination of these documents would lead a person skilled in the art to the invention defined in the claims.

Therefore, the invention defined in claims 1-10 is novel and is considered to involve an inventive step. It is also considered to be industrially applicable.

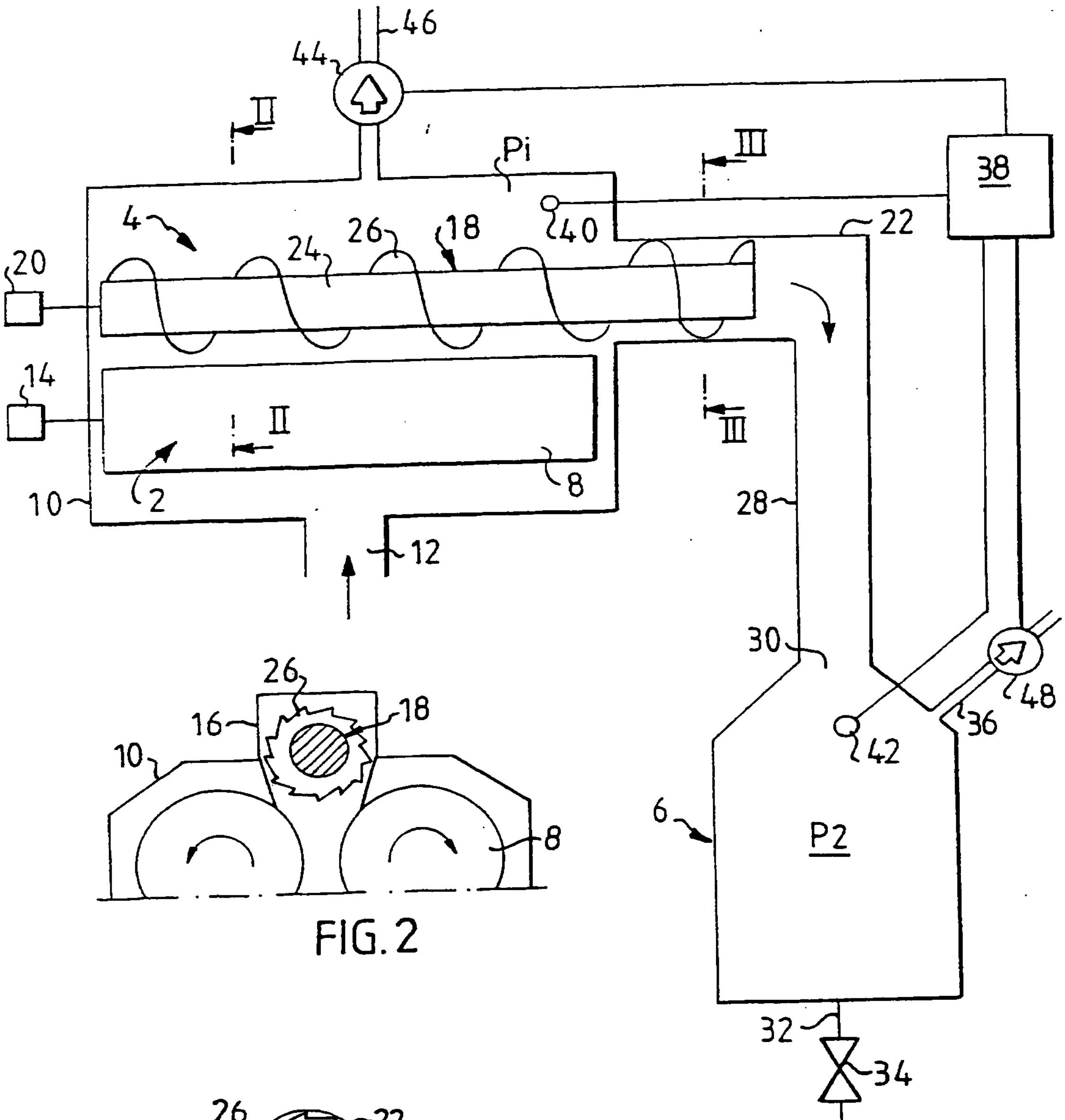

FIG.1

FIG.2

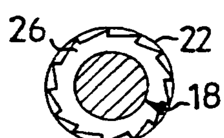

FIG.3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE 00/01052

A. CLASSIFICATION OF SUBJECT MATTER

IPC7: D21C 9/153, D21C 7/06
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: D21C

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 9605365 A1 (INGERSOLL-RAND COMPANY), 22 February 1996 (22.02.96), page 2, line 22 - page 4, line 24 --	1-10
A	US 4278496 A (BRØRN H. FRITZVOLD), 14 July 1981 (14.07.81), column 3, line 7 - line 27 -- --------	1-10

☐ Further documents are listed in the continuation of Box C. ☒ See patent family annex.

* Special categories of cited documents:
"A" document defining the general state of the art which is not considered to be of particular relevance
"E" erlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
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INTERNATIONAL SEARCH REPORT
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International application No.
PCT/SE 00/01052

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
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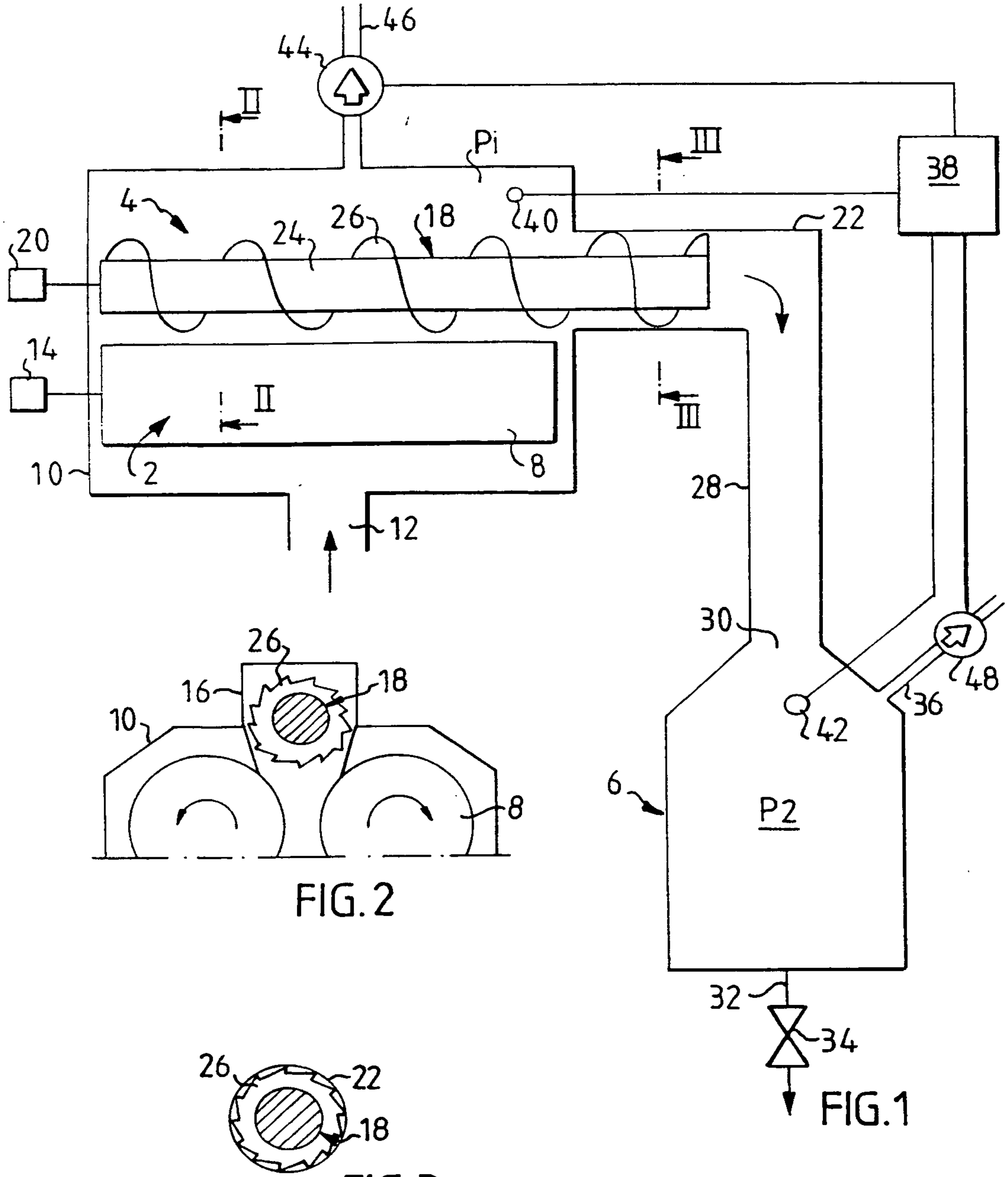

FIG.1

FIG.2

FIG.3

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
21 December 2000 (21.12.2000)

PCT

(10) International Publication Number
WO 00/77296 A1

(51) International Patent Classification[7]: D21C 9/153, 7/06

(21) International Application Number: PCT/SE00/01052

(22) International Filing Date: 24 May 2000 (24.05.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9902178-4 10 June 1999 (10.06.1999) SE

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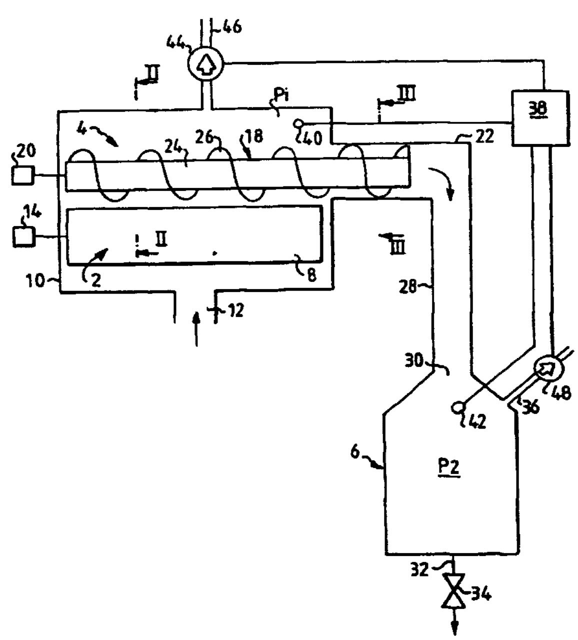
(81) Designated States *(national)*: AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, DZ, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW.

(84) Designated States *(regional)*: ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published:
— *With international search report.*
— *Before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: METHOD AND SYSTEM FOR CONVEYING SHREDDED PULP TO AN OZONE REACTOR



(57) Abstract: A system for treatment of pulp comprises a dewatering device (2) for dewatering the pulp to a fibre concentration of at least 20 %, a reaction vessel (6) for bleaching the dewatered pulp through reaction with ozone gas and a pulp shredding device (4) for shredding the dewatered pulp before the latter is supplied to the reaction vessel. The pulp shredding device has a closed pulp shredding vessel (16), an outlet pipe (22) and a transport means (18) for continuous transport of the shredded pulp without compression out of the pulp shredding vessel via the outlet pipe, so that the latter kept filled with passing pulp. A conduit (28) gas sealed from the surroundings connects the outlet pipe (22) gas-tightly to the reaction vessel (6). A pressure regulation device (38, 40, 42, 44, 48) maintains a gas pressure (P1) in the pulp shredding vessel which is higher than the gas pressure (P2) in the reaction vessel.

WO 00/77296 A1

PCT

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International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 6 : D21C

A2

(11) International Publication Number: WO 97/05324

(43) International Publication Date: 13 February 1997 (13.02.97)

(21) International Application Number: PCT/US96/12903

(22) International Filing Date: 16 July 1996 (16.07.96)

(30) Priority Data:
60/001,446 26 July 1995 (26.07.95) US

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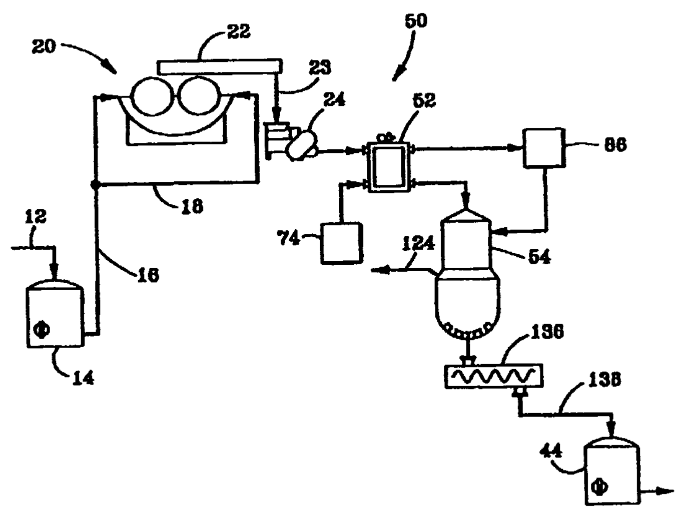
(81) Designated States: AT, CA, FI, JP, SE, US, European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published
Without international search report and to be republished upon receipt of that report.

(54) Title: METHOD AND APPARATUS FOR BLEACHING HIGH CONSISTENCY PULP WITH A GASEOUS BLEACHING REAGENT



(57) Abstract

A method and apparatus for bleaching hig consistency pulp with a gaseous bleaching reagent. The pulp is shredded and then fluffed in the presence of a contacting gas which includes the gaseous bleaching reagent within an upstream vessel (52) comprising a pin/foil contactor so as to suspend the pulp in the contacting gas and react the bleaching reagent with the pulp. The pulp is retained in the contactor for a predetermined time which is sufficient to consume about 75 % to about 90 % of a selected dose of the gaseous bleaching reagent which is required to delignify the high consistency pulp from an initial Kappa number to an intermediate Kappa number. The pulp and contacting gas are then separately supplied to a porous bed reactor where the reaction of the selected dose of the gaseous bleaching reagent with the pulp is substantially completed so as to further delignify the high consistency pulp from the intermediate Kappa number to a final Kappa number.

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METHOD AND APPARATUS FOR BLEACHING HIGH CONSISTENCY PULP WITH A GASEOUS BLEACHING REAGENT

CROSS-REFERENCES

The subject application is a continuation-in-part of U.S. Provisional Patent Application having Serial No. 60/001,446 filed on July 26, 1995, entitled: "Ozone Bleaching System Combining Pin Fluffer And Bed Reactor", and is related to the following co-pending and commonly assigned U.S. Patent Applications which are expressly incorporated by reference herein: Serial No. 08/125,053 filed on September 21, 1993, entitled "Apparatus For Fluffing High Consistency Wood Pulp"; Serial No. 08/335,282 filed on November 7, 1994, entitled "Apparatus For Fluffing And Contacting High Consistency Wood Pulp With a Gaseous Bleaching Reagent"; and Serial No. 08/398,317 filed on March 3, 1995, entitled "Variable Angle Powered Cyclone".

BACKGROUND OF THE INVENTION

1.0 Field of the Invention

The present invention relates generally to the bleaching of lignocellulosic materials for use in the pulp and paper industry, and more particularly to a method and apparatus for bleaching high consistency pulp with a gaseous bleaching reagent such as ozone.

2.0 Related Art

The use of gaseous reagents, including chlorine dioxide and ozone, for the bleaching of lignocellulosic materials including wood pulp is well known in the art. It is further known, particularly with respect to the bleaching of high consistency wood pulp, that mechanical mixing of the pulp in the presence of the bleaching reagent is required to enhance the rate of reaction between the bleaching reagent and the pulp and to achieve uniformity of the resultant bleached pulp.

As known in the art, wood pulp is obtained from the digestion of wood chips or from repulping of recycled paper or from other sources and is commonly processed in pulp and paper mills in slurry form in water. As used herein, the term "consistency" is used to express the measured ratio of dry pulp fibers to water, or more specifically, the weight of dry pulp fiber in a given weight of pulp slurry or "pulp stock" as a percentage. Various definitions are used, such as air-dry consistency (a.d.%), or oven-dry consistency (o.d.%), or moisture-free consistency (m.f.%). The laboratory techniques for measuring these values can be found in references well known in the art, such as the TAPPI Standards Manual. Terms widely used to describe ranges of stock consistency useful in pulp and paper plants follow:

Low Consistency - below about 4-6% o.d. Medium Consistency - about 9-18% o.d.

High Consistency - above about 18-20% o.d., but more commonly above about 25% o.d.

The primary characteristic of pulp slurries which changes with consistency is the fluidity. Low consistency slurries flow like water and can easily be pumped through pipelines using normal centrifugal pumps. In contrast, medium consistency pulp slurries have a paste-like character, do not flow by gravity, and can only be pumped in pipelines by using specially designed pumps. Also in contrast, wood pulp in the high consistency range does not have a slurry-like character, but is better described as a damp, fibrous, solid mass. Upon superficial examination, high consistency wood pulp appears to be and act like a dry solid. Accordingly, high consistency wood pulp generally cannot be pumped through any great distance in pipelines because the pipe wall friction is very high, resulting in uneconomic pumping horsepower requirements. However, this characteristic is used to advantage in some prior art bleaching systems which feed high consistency pulp to a gas filled vessel through a short length of pipe in which the pulp forms a plug sufficiently impermeable to prevent loss of reaction gas in the reverse direction. High consistency wood pulp has an additional characteristic which is that it can be fluffed, in the same way that dry fibrous solids such as cotton or feathers can be fluffed, to give a light and porous mass, the inner fibers of which are accessible to a chemical reagent in gaseous form. Fluffed, high consistency pulp can be blown with air or bleaching gases through pipelines provided sufficient velocity is used to prevent the wet fibers from settling out of the gas suspension. It is understood in the art

that the agitation of pulp, for the aforementioned reasons, requires the expenditure of energy and increases the pulp processing costs both with regard to the initial capital investment and with regard to equipment maintenance costs in proportion to the degree of mechanical effort expended.

One known system for bleaching high consistency pulp with chlorine dioxide includes a device commonly referred to as a fluffer/blower. The pulp is mechanically fluffed within the fluffer/blower in the presence of the chlorine dioxide and the associated carrier gas so as to form a gas-suspended mixture for transport and initiation of the bleaching reaction. The gas-suspended pulp is then transported through a conduit to the top of a reactor tower, of the porous bed type. A relatively high transport velocity is required within the conduit and accordingly the flow within the conduit is turbulent in nature, which maintains the pulp in a gas-suspended mixture and continues the reaction of the pulp with the chlorine dioxide. The pulp then enters an upper portion, commonly referred to as a cyclone, of the porous-bed reactor tower in a tangential manner, causing the gas-suspended pulp to swirl around the inner wall of the reactor tower cyclone, so as to further react the pulp with the chlorine dioxide and at the same time to separate the pulp from an excess of gas required for transport, with the excess gas being returned to the fluffer/blower. The pulp then drops onto a porous bed of fluffed pulp, within the reactor tower, which continuously moves downward through the reactor

tower toward an expanded section which acts as a gas separation chamber. The total residence time of the pulp within the fluffer/blower, the transport conduit and the reactor tower cyclone (prior to the pulp dropping onto the porous bed of fluffed pulp) is approximately 5 seconds. Notwithstanding the relatively short combined pulp residence time a substantial portion of the chlorine dioxide, comprising about 60% to about 80% of a given chlorine dioxide dose, is consumed within the fluffer/blower, transport conduit and reactor tower cyclone due to the very fast reaction rate characteristics of chlorine dioxide. The chlorine dioxide and carrier gas flow downward through the porous bed at a substantially higher velocity than that at which the pulp bed moves downward through the reactor, so as to substantially complete the reaction of the chlorine dioxide with the pulp. The carrier gas then flows into a gas separation chamber within the reactor and is subsequently recycled. Although bleaching systems of this type have proven somewhat effective for the bleaching of high consistency pulp with chlorine dioxide, they are subject to the following limitations. The pulp residence time within the fluffer/blower is substantially fixed and is controlled by the fluffer speed required to achieve shredding and fluffing of the pulp. The pulp residence time within the transport conduit interconnecting the fluffer/blower and the bed reactor is also substantially fixed (without an impractical increase in conduit length) due to the transport velocity required within the conduit. Accordingly, such systems provide limited flexibility with

regard to the ability to vary pulp residence time, while the pulp is agitated and maintained suspended in the gaseous bleaching reagent.

Recently, there have been many efforts to utilize ozone as the bleaching reagent for high consistency wood pulp, and other lignocellulosic materials, to avoid the use of chlorine (and the attendant environmental problems) in such bleaching processes. Although ozone may initially appear to be an ideal material for bleaching lignocellulosic materials, the exceptional oxidative properties of ozone and its relatively high cost have limited the development of satisfactory devices and processes for ozone bleaching of lignocellulosic materials. For instance, the inventors have determined that the previously described system for bleaching high consistency wood pulp with chlorine dioxide does not provide optimum results when bleaching with ozone, due to the aforementioned inflexibility regarding pulp residence time with the pulp in an agitated, gas-suspended state. Also, a large amount of energy is required, in addition to that expended in fluffing the pulp, to transport the gas suspension of pulp from the fluffer/blower to the top of the bed reactor.

The foregoing illustrates limitations known to exist in present wood pulp bleaching operations. Thus, it is apparent that it would be advantageous to provide an alternative directed to overcoming one or more of the limitations set forth above. Accordingly, a suitable

alternative is provided including features more fully disclosed hereinafter.

SUMMARY OF THE INVENTION

In one aspect of the present invention, this is accomplished by providing a method for bleaching high consistency pulp with a gaseous bleaching reagent comprising the steps of:

supplying a high consistency pulp to a first, upstream vessel;

shredding the pulp within the upstream vessel in the presence of a contacting gas including the gaseous bleaching reagent, a carrier gas, and reaction by-product gases so as to suspend the pulp in the contacting gas and to initiate reaction of the gaseous bleaching reagent with the pulp;

fluffing the shredded pulp within the upstream vessel in the presence of the contacting gas so as to maintain the pulp in suspension in the contacting gas and to further react the gaseous bleaching reagent with the pulp, wherein said step of fluffing includes the steps of

creating a rotating annulus of fluidized particles of the shredded pulp within the upstream vessel,

combing the rotating annulus of fluidized particles of the shredded pulp so as to further reduce the size of the shredded pulp particles and to fluff the pulp particles;

retaining the high consistency pulp within the upstream vessel for a predetermined time which is

sufficient to consume about 75% to about 90% of a selected dose of the gaseous bleaching reagent which is required to delignify the high consistency pulp from an initial Kappa number to an intermediate Kappa number; and

discharging the fluffed pulp and the contacting gas from the upstream vessel to a second, downstream vessel in which the reaction of the selected dose of the gaseous bleaching reagent with the pulp is substantially completed so as to further delignify the high consistency pulp from the intermediate Kappa number to a final Kappa number.

According to a second aspect of the present invention, this is accomplished by providing a system for bleaching high consistency pulp with a gaseous bleaching reagent, with the system comprising:

a substantially vertical pin/foil contactor having a gas inlet, a gas outlet, a pulp inlet, and a pulp outlet;

means for supplying high consistency pulp to said pulp inlet of said contactor;

means for supplying fresh bleaching gas to said gas inlet of said contactor; and

a porous bed reactor having a gas inlet, a gas outlet, a pulp inlet, and a pulp outlet, wherein said gas inlet of said reactor is in fluid communication with said gas outlet of said contactor and wherein said pulp inlet of said reactor communicates with said pulp outlet of said contactor; and

wherein said contactor further includes means for shredding the high consistency pulp supplied to said pulp

inlet of said contactor and means for fluffing the shredded pulp.

BRIEF DESCRIPTION OF THE DRAWINGS

The foregoing and other aspects of the present invention will become more apparent from the subsequent Detailed Description of the invention when considered in conjunction with the accompanying drawing figures, wherein:

Fig. 1 schematically illustrates a prior system for bleaching lignocellulosic materials, such as high consistency wood pulp, with a gaseous bleaching reagent;

Fig. 2 graphically illustrates the kinetics of the reaction of ozone with high consistency high consistency wood pulp, for various ozone in carrier gas concentrations in a continuous co-current plug flow reactor;

Fig. 3 schematically illustrates a system for bleaching lignocellulosic materials, such as high consistency wood pulp, with a gaseous bleaching reagent, according to the present invention;

Fig. 4 is an elevational view, partly in cutaway view, further illustrating a portion of the pulp bleaching system shown in Fig. 3;

Fig. 5 is a partial, perspective view further illustrating a portion of the pulp bleaching system shown in Fig. 4;

Fig. 6 illustrates the ozone bleaching kinetics within the apparatus of the present invention and compares the effects of co-current and counter-current flow of ozone in an upstream, or first stage bleaching vessel, followed by concurrent flow of ozone in a downstream, or second stage bleaching vessel.

DETAILED DESCRIPTION

Referring now to the drawings, Fig. 1 schematically illustrates a prior art system 10 for bleaching lignocellulosic materials, such as high consistency wood pulp, with a gaseous bleaching reagent comprising chlorine dioxide. Wood pulp 12 enters a press feed tank 14 where it is diluted with pressate to form a pulp slurry having a consistency of about 4%. Sulfuric acid is added to the pulp slurry within tank 14 so as to reduce the pH of the pulp slurry to about 2-3. The pulp slurry is then transported, via conduits 16 and 18, to a twin roll dewatering press, such as an IMPCO Vari-Nip® twin roll press made by the Beloit Corporation. The pulp is then shredded in a double flight conveyor 22 and transported externally of press 20 where it drops into a thick stock pump 24 such as an IMPCO Clove-Rotor® thick stock pump made by the Beloit Corporation. The high consistency pulp discharging from pump 24 is supplied to a fluffer/blower

26 via conduit 28. The fluffer/blower 26 includes means for disintegrating, or shredding the high consistency pulp into relatively small flocs and also fluffs the pulp in the presence of a bleaching gas including a gaseous bleaching reagent, comprising chlorine dioxide, and a carrier gas, so as to suspend the fluffed pulp in the bleaching gas. A flow of bleaching gas is supplied to the fluffer/blower 26 from an upper portion 30 of a substantially vertically oriented porous bed reactor 32 via conduit 34. Fresh bleaching gas i6 supplied to conduit 34 from a source 36 of chlorine dioxide via conduit 38. The reaction of the chlorine dioxide with the high consistency pulp is initiated in the fluffer/blower 26 and continues in the conduit 40, used to transport the gas-suspended pulp to reactor 32, and in the upper portion 30 of the reactor 32. The flow through conduit 40 is turbulent in nature which agitates the pulp and maintains the pulp in a gas-suspended mixture with the chlorine dioxide and the associated carrier gas. The gas-suspended pulp enters the upper portion 30 of reactor 32 from conduit 40 in a tangential manner 80 that the gas-suspended pulp swirls around the inner wall of the upper portion 30 of reactor 32 in a cyclonic fashion. Hence, portion 30 may be referred to in the art as a cyclone. The pulp then drops onto a porous bed of fluffed pulp (not shown) within reactor 32, and the pulp bed moves continuously downward through reactor 32. Since the flow of gas required for pulp transport through conduit 40 is usually much larger than the fresh bleaching gas entering from conduit 38, the excess gas is separated from the pulp

in cyclone 30 and returned to the fluffer/blower 26 through conduit 34. The inventors have determined that the combined pulp residence time within the fluffer/blower 26, conduit 40 and the upper portion 30 of reactor 32 (prior to the pulp falling on the fluffed bed) is approximately 5 seconds. Due to the agitation of the pulp, and consequently the intimate contact of the pulp with the chlorine dioxide, within the fluffer/blower 26, conduit 40 and the upper portion 30 of reactor 32, about 60% to about 80% of a given dose of the chlorine dioxide is consumed within fluffer/blower 26, conduit 40 and the upper portion 30 of reactor 32. This relatively large percentage of chlorine dioxide is consumed, notwithstanding the relatively short pulp residence time, since the reaction rate of chlorine dioxide with pulp is very fast. Substantially all of the remaining chlorine dioxide is consumed as the chlorine dioxide passes through the fluffed pulp bed, at a substantially higher velocity than that at which the bed moves downward through reactor 32. The fluffed bed of pulp may reside in reactor 32 for a relatively long time, on the order of several minutes, to substantially complete the reaction of the chlorine dioxide with the pulp due to the characteristic "tail" of the chlorine dioxide bleaching kinetics curve, which is known in the art. A dilution liquor, indicated by flow arrow 41, may be added to a lower portion of reactor 32 so as to achieve a desired consistency of the pulp for further processing. The manner in which the pulp discharges from reactor 32 depends on the requirements of the subsequent bleaching stage of the associated

processing plant. In the system 10 shown in Fig. 1, the pulp is extracted from reactor 32 using a dilution scraper 42, with the diluted pulp then being transferred to a receiving tank 44 via conduit 46. The pulp may then discharge tank 44, after appropriate treatment, for further processing as shown by flow arrow 48. Any remaining chlorine dioxide which has not been consumed, as well as the associated carrier gas, discharges into an annular gas separation chamber 47 of reactor 32 and discharges from chamber 47 for further processing, as shown by flow arrow 49.

Although system 10 has been used with success in certain applications, such as the aforementioned bleaching of high consistency pulp with chlorine dioxide, it is subject to the following limitations. The pulp residence time within the fluffer/blower 26 is substantially fixed and is controlled by the rotational speed which is required to achieve disintegration and fluffing of the high consistency pulp supplied to fluffer/blower 26. The pulp residence time within transport conduit 40 is also substantially fixed (without an impractical increase in conduit length) due to the relatively high transport velocity required within conduit 40. Accordingly, system 10 provides very limited flexibility with regard to changing the pulp residence time prior to contacting the fluffed bed of pulp within reactor 32.

The inventors have experimentally determined the bleaching kinetics of ozone, or the rate of reaction of

ozone with high consistency pulp, which is shown in Fig. 2 for a variety of concentrations of ozone in an oxygen carrier gas ranging from 6% ozone concentration to 14% ozone concentration. This range of ozone concentrations represents those which are presently commercially available and economically feasible in the required quantities for the commercial bleaching of high consistency wood pulp, with 6% ozone concentration presently being particularly attractive from a cost standpoint. However, it is noted that ozone generator technology is rapidly changing and that accordingly, other concentrations of ozone may become economically viable in the future. The data presented in Fig. 2 was experimentally determined as follows. A laboratory scale batch apparatus was built to measure ozone consumption in a mechanically agitated bleaching contactor at residence times as short as 2 seconds. Ozone delignifications were run at various gas concentrations and residence times using a Canadian softwood Kraft pulp which had been oxygen delignified in the laboratory to 10.5 Kappa number. The contactor included a 5 liter capacity reaction chamber, suitable for accepting a charge of approximately 100 g o.d. fluffed pulp. The Kraft-oxygen pulp samples were well washed, acidified to pH 2 with sulfuric acid at low consistency and then dewatered in a press to 40% o.d. Portions of the pulp cake were weighed out and then fluffed immediately prior to each run in the contactor. The dewatered, fluffed pulp was manually charged into the reaction chamber which was then closed. Air was evacuated with a vacuum pump and a high-speed (1750 rpm) rotor

fitted with pointed pins and rotatably mounted within the reaction chamber, was started. Next, a quick opening valve allowed the ozone/oxygen gas to rush in from an accumulator. This was followed by a reaction period at constant pressure and the rotor kept the fluffed pulp rotating in a layer against the inner wall of the reaction chamber and imparted a combing action to the fiber flocs. Next, a fast nitrogen purge expelled residual gas to a second accumulator for titration. The combined inrush and reaction period was varied from about 2 seconds to about 60 seconds in successive runs. The ozone gas charge was calculated from the initial and final pressures and the known volume of the reaction chamber, and its concentration by titrating a volumetric sample from the feed accumulator. The total residual ozone was obtained from titration of samples from the purged gas accumulator. The consumed ozone was the difference of these two calculations.

The inventors have determined that for optimum bleaching results using ozone, that it is desirable to consume about 75% to about 90%, and more preferably about 80% to about 90%, of the ozone dose while the high consistency pulp is being agitated and suspended within the ozone, which contrasts with the 60% to 80% of chlorine dioxide consumed in system 10 during the period of time that the pulp is suspended in the chlorine dioxide within fluffer/blower 26, transport conduit 40 and the cyclone, or upper portion 30 of the porous bed reactor 32. As shown in Fig. 2, the time required to achieve the more preferred

range of about 80% to about 90% ozone consumption, for a given ozone dose, varies from about 5 seconds to about 20 seconds, depending upon the concentration of the ozone used. Also as shown in Fig. 2, if the concentration of the ozone is 6%, which is presently economically attractive, the time required to achieve 80% to 90% ozone consumption varies from about 10 second to about 20 seconds. Accordingly, based on the combined pulp residence time of about 5 seconds within fluffer/blower 26, transport conduit 40 and the cyclone 30 of reactor 32, in combination with the aforementioned limited flexibility of system 10 to vary the pulp residence time within the fluffer/blower 26 and transport conduit 40, the inventors have determined that system 10 is not adequate for producing optimum results when bleaching high consistency wood pulp with ozone.

Referring now to Figs. 3, 4, and 5 a system 50 for bleaching lignocellulosic materials, such as high consistency wood pulp, with a gaseous bleaching reagent, is illustrated according to a preferred embodiment of the present invention. System 50 is shown in schematic form in Fig. 3, and specific details of construction of portions of system 50 are further illustrated in Figs. 4 and 5. As described herein, the apparatus of the present invention depicted in the illustrative embodiment shown in Figs. 3-5, will be described in conjunction with a method for bleaching high consistency wood pulp utilizing ozone as the gaseous bleaching reagent, according to the method of the present invention. The apparatus and method of the

present invention are not intended to be utilized for the bleaching of either medium consistency or low consistency wood pulp. As known in the art, due to the manner in which ozone is generated, ozone is typically available at a relatively low concentration within a carrier gas, such as oxygen or air. Typically, the concentration of ozone which is presently commercially available at attractive costs, ranges from about 6% to about 10% by weight when using oxygen as the carrier gas. As used herein, the term "contacting gas" will refer to the mixture of ozone in an oxygen carrier gas, as well as other gases and vapors, such as by-product gases of reaction, which are present at equilibrium conditions. The term "fresh bleaching gas" will be used to denote a mixture of ozone in an oxygen carrier gas supplied from a conventional source, such as a dryer/cleaner and ozone generator, which has not been reacted with the pulp and accordingly does not include reaction by-product gases.

The operation of system 50 is the same as that of system 10 up to the point where the high consistency pulp discharges from the Clove-Rotor® pump 24. As seen by comparing Figs. 1 and 3, system 50 does not include the fluffer/blower 26, or the transport conduits 34 and 40 of system 10. Instead, after the high consistency pulp is discharged from the pump 24 in system 50, the high consistency pulp is bleached with ozone within a first, upstream vessel 52 and is then bleached within a second, downstream vessel 54, as subsequently described.

Referring again to Figs. 3-5, a high consistency wood pulp 23 is supplied from the dewatering press 20 to the Clove-Rotor® pump 24 which operates in a manner well known in the art. Pump 24 forces the high consistency pulp 23 through a pipe 58 and into a pulp inlet 56 of vessel 52. Due to the frictional resistance of the pulp 23 within pipe 58, an impervious moving pulp plug is formed within conduit 58 which is effective for preventing the back-flow of contacting gas from vessel 52. plug

Vessel 52 comprises a pin/foil contactor and is substantially vertically oriented as shown in Fig. 4. Contactor 52 includes a housing 62 and a shaft 63 which is rotatably mounted within housing 62. Shaft 63 is rotatably driven by a motor 66 which may comprise a variable-speed motor. A rotor drum 64 is attached to shaft 63 for rotation with shaft 63. The housing 62 includes an upper portion 68, comprising a gas separation chamber, and a lower portion 70 with means contained therein for shredding the high consistency pulp supplied through pulp inlet 56 and for fluffing the pulp within the presence of a contacting gas including ozone, an oxygen carrier gas and by-product of reaction gases. Fresh bleaching gas, comprising ozone in an oxygen carrier gas, is supplied to a gas inlet 72 of contactor 52 from a source 74 of fresh bleaching gas via a conduit 76. The source 74 of fresh bleaching gas may comprise an ozone generator and a dryer/cleaner. A helically disposed screw flight 78 is attached to drum 64 for rotation therewith and is disposed below the gas separation chamber 68 and extends through an

upper portion of the lower portion 70 of housing 62. The screw flight 78 is substantially aligned with the pulp inlet 56 of contactor 52, and includes a plurality of teethlike surfaces disposed along the outer periphery of screw flight 78. Accordingly, screw flight 78 is effective for shredding the high consistency pulp entering through inlet 56 into relatively small particles. Screw flight 78 is also effective for imparting a circumferential velocity to the pulp particles within housing 62. Contactor 52 further includes a plurality of pins 80 which are attached to drum 64 and extend radially outwardly from drum 64 to a location proximate an inner wall 71 (shown in Fig. 5) of the lower portion 70 of housing 62. The pins rotate with shaft 63 and drum 64 about an axially extending, substantially vertical centerline axis 82 of contactor 52. Pins 80 are disposed in a plurality of axially spaced rows, with each axial row including a plurality of circumferentially spaced pins 80. The rotating action of the screw flight, or shredder 78 as well as the centrifugal force exerted on the shredded pulp by the rotating action of pins 80, forces the pulp radially outward against the inner wall 71 of the lower portion 70 of housing 62. A rotating annulus of fluidized particles of the shredded pulp is created in an annular space 84 which exists between the inner wall 71 of lower portion 70 of housing 62 and the rotor drum 64. The rotating annulus of pulp is rotatable about the centerline axis 82 of contactor 52, and has a tangential velocity which is less than that of the tips of pins 80. As shaft 63 and drum 64 are rotated, the tips of pins 80 comb through the annulus

of pulp, so as to further reduce the size of the shredded pulp particles and to fluff the pulp particles in the presence of the contacting gas within housing 62. Accordingly, the fluffed pulp is maintained in a fluidized state within the contacting gas as it swirls around the inner wall of the lower portion 70 of housing 62 and moves downward through annulus 84. The ozone and oxygen carrier gas which enters housing 62 through gas inlet 72, flows upward through housing 62 in a countercurrent relationship with the pulp, which is moving downward through housing 62. The countercurrent flow of the contacting gas within housing 62 is induced by a blower 86 which is in fluid communication with a gas outlet 88 of contactor 52 via conduit 90. The gas outlet 88 is in fluid communication with the gas separation chamber 68 of contactor 52. The contacting gas discharging from contactor 52 to blower 86 is then supplied to a gas inlet 92 of the downstream vessel 54 via conduit 94.

The substantially vertical pin/foil contactor 52 further includes a plurality of circumferentially spaced columns of guide foils 96, with one of the columns being partially shown in perspective view in Fig. 5. The number of columns of guide foils 96 may vary with application. Each column of guide foils 96 includes a plurality of axially aligned and axially spaced guide foils 96, as shown in Fig. 5. The presence of guide foils 96 permits the substantially vertical pin/foil contactor 52 to be cylindrical in design, rather than conical, for instance. More specifically, guide foils 96 allow the desired pulp

residence time within contactor 52 to be achieved. Without guide foils 96, the pulp would precipitously fall through contactor 52 in a very short period of time, preventing the desired bleaching of the pulp within contactor 52. The guide foils 96 of each column may be attached to a mount plate 98, which in turn is attached to the inner wall 71 of the lower portion 70 of housing 62. Each guide foil 96 includes a first, substantially flat portion 100 and a second, arcuate portion 102 which is curved upward relative to the flat portion 100 and functions in a manner similar to that of an airfoil by imparting lift to the fluffed pulp as it slides past each guide foil 96. As shown in Fig. 4, guide foils 96 are interleaved with pins 80 so that pins 80 and guide foils 96 are disposed in a vertically alternating arrangement. The vertically alternating arrangement of pins 80 and foils 96 extend substantially throughout the axial length of the lower portion 70 of housing 62. Each guide foil 96 further includes a leading edge 104, formed on the substantially flat portion 100. The leading edge 104 forms a shallow, radially inwardly diverging angle relative to a radial line, which serves to retard the development of pulp plugs and to promote the shedding of fiber build-up that would otherwise develop on a square leading edge. Additionally, the geometry of foils 96 i8 such that foils 96 exert a minimal drag on the rotating annulus of fluidized pulp particles so as not to retard the circumferential velocity of the rotating annulus of fluidized pulp particles. Furthermore, the projected frontal area of foils 96 is significantly smaller than that of pins 80 which is

important as this relative sizing of foils 96 and pins 80 permits the formation of the rotating annulus of fluidized pulp particles. In a preferred embodiment, the projected frontal area of foils 96 is about one-fourth, or less, than the projected frontal area of pins 80. The projected frontal area of foils 96 is minimized consistent with the structural requirements of foils 96 and with the extent of the arcuate portion 102 of each foil 96 which is required to impart the desired lift to the fluffed pulp as it slides past each guide foil 96. Foils 96 are discussed and further illustrated (as element 25) in co-pending and commonly assigned U.S. Patent Application having Serial No. 08/335,282.

As discussed previously, the inventors have determined that for purposes of enhanced uniformity of the bleached pulp, it is desirable to consume about 75% to about 90%, and more preferably about 80% to about 90%, of a given ozone dose while the pulp is in an agitated, gas-suspended mixture, such as that which exists within contactor 52. Accordingly, the pulp is retained within contactor 52 for a predetermined time which varies depending upon the desired percentage of ozone consumption and the ozone concentration. For instance, in order to achieve the more preferred range of about 80% to about 90% of ozone consumption within contactor 52, the pulp residence time within contactor 52 ranges from about 5 seconds to about 20 seconds for ozone concentrations ranging from 6% to 14%, due to the ozone bleaching kinetics shown in Fig. 2 which were experimentally

determined by the inventors. This pulp residence time within contactor 52 may be achieved by varying the speed of motor 66, and the corresponding rotating speed of pins 80, as well as varying the flow rate of the bleaching gas supplied to inlet 72 of contactor 52 and the design of guide foils 96. The inventors have determined that the use of the substantially vertical pin/foil contactor 52 provides excellent results, with respect to uniformity of pulp bleaching, for the following reason. The intense agitation of the pulp with pins 80 causes the pulp to be maintained in suspension in the contacting gas in the form of a fluidized solid disposed in the annular space 84 between the rotor drum 64 and the inner wall 71 of the lower portion 70 of housing 62. Accordingly, all of the pulp is in intimate contact with the ozone bleaching reagent throughout the entire pulp residence time within contactor 52.

The pulp particles are discharged from contactor 52 through a tangentially oriented pulp outlet 106 of contactor 52. The circumferential velocity imparted to the pulp as it travels downward through housing 62 causes the pulp particles to be flung tangentially through outlet 106 into an elbow-shaped conduit, or pipe 108 which is attached at one end to a substantially vertically oriented pulp inlet 110 of the downstream vessel 54, which comprises a porous bed reactor. Virtually no contacting gas discharges from outlet 106 of contactor 52. Instead, as discussed previously, the contacting gas is separated from the pulp within gas separation chamber 68 and is then

routed to the gas inlet 92 of the porous bed reactor 54 via conduits 90 and 94 and blower 86. The fluffed pulp entering reactor 52 through inlet 110 drops onto a porous bed 112 of fluffed pulp, which moves continuously downward through the porous bed reactor 54. The contacting gas flows through the porous bed at a substantially higher velocity than that of the bed, so as to substantially complete the reaction of the pulp with the ozone. The pulp residence time within reactor 54 may be varied, by varying the fill level of the pulp within reactor 54, for instance, so that about 95% to about 97% of a given ozone dose is consumed after the contacting gas has passed through the porous bed. The oxygen carrier gas, and any remaining ozone which has not been consumed, then discharges into an annular gas separation chamber 114, as indicated by flow arrows 116. The gas separation chamber 114 is formed at the interface between the relatively smaller diameter, generally cylindrical upper portion 118 of reactor 54 and the relatively larger diameter, generally cylindrical lower portion 120 of reactor 54. The gas entering the gas separation chamber 114 then discharges reactor 54 through a gas outlet 122, as shown by flow arrow 124, with the gas being recycled for further processing. For instance, the gas discharging from outlet 122 may be supplied to a dryer/cleaner and ozone generator so that the oxygen carrier gas may be reused. The bleached pulp 126 at the bottom of reactor 54 then discharges reactor 54 through a pulp outlet 128 as shown by flow arrow 130, for further processing. The selection of the apparatus used to discharge the pulp from reactor 54

depends on the requirements of the following bleaching system. If the pulp will be washed prior to the next bleach stage, the pulp is diluted with pressate, indicated by flow arrow 132 in Fig. 4, to about 6% consistency, and is then discharged from reactor 54 to a mix tank (not shown in Fig. 4) using a dilution scraper 134 mounted within a lower portion of reactor 54. On the other hand, if the pulp will be subsequently processed in a medium consistency bleach tower, it may be extracted to a twin screw discharger device, such as the screw-type conveyor 136 shown in Fig. 3, transported to a tank 44 via a conduit, or pipe 138, and then diluted within tank 44 to about 12% consistency for subsequent supply to a thick stock pump (not shown) downstream of tank 44.

Fig. 6 presents a comparison of ozone consumption as a function of pulp residence time for a two-stage ozone bleaching system such as that which is achieved within contactor 52 and reactor 54. The graphs indicated by solid squares and solid triangles correspond, respectively, to ozone concentrations of 6% and 10%, for a system having countercurrent flow of the ozone relative to the pulp in the first stage and co-current flow of the ozone relative to the pulp in the second stage, such as that discussed previously with respect to contactor 52 and reactor 54. The graphs shown with the letter X and open circles correspond, respectively, to ozone concentrations of 6% and 10% for a system having co-current flow of the ozone through both "stage" of bleaching. As shown in Fig. 6, for each ozone concentration, the system employing

countercurrent flow of ozone in the first stage of bleaching results in greater ozone consumption, for a given pulp residence time, than the system having full co-current flow of the ozone relative to the pulp. The graphs shown in Fig. 6 were developed by the inventors by utilizing the experimentally determined ozone kinetics shown previously in Fig. 2, in conjunction with associated empirically determined bleaching rate constants and a computer simulation which permitted extrapolation of the data obtained with a single batch contactor, to a system having two continuous reactors. Each of the graphs shown in Fig. 6 corresponds to a Kraft softwood pulp which had been oxygen delignified in the laboratory to an initial Kappa No. of 10.3 and had a final Kappa No. of 3.8 after 97% of the ozone dose (which is shown in dashed lines in Fig. 6) was consumed. The ozone dose was equal to 0.5g/100 g o.d. pulp. Intermediate Kappa Nos. of 4.8 and 4.2 were realized after 80% and 90%, respectively, of the ozone dose was consumed. The inventors have also determined that for a Kraft softwood pulp which had been partially delignified with oxygen to an initial Kappa No. of 18, the application of an ozone dose of 0.9g/100 g. o.d. pulp resulted in a final Kappa No. of 4.0, after 97% of the ozone dose was consumed, in a simulated system having countercurrent flow of the ozone relative to the pulp in the first stage and co-current flow of the ozone relative to the pulp in the second stage, such as that discussed previously with respect to contactor 52 and reactor 54. In this case, intermediate Kappa Nos. of 6.8 and 5.5 were

achieved after consumption of 80% and 90%, respectively, of the ozone dose.

In operation, the pulp residence time within pin/foil contactor 52 is controlled so that about 80% to about 90% of a given ozone dose is consumed within contactor 52 while the pulp is in an agitated, gas-suspended mixture, which results in uniformly bleached pulp. The residence time required to achieve this ozone consumption ranges from about 5 seconds to about 20 seconds within contactor 52, depending on the concentration of ozone used. Accordingly, contactor 52 accomplishes an even greater retention time than that existing in the fluffer/blower 26, conduit 40 and cyclone 30 of the prior chlorine dioxide system shown in Fig. 1. Additionally, the pulp shredding and fluffing accomplished in the prior fluffer/blower 26 of Fig. 1, as well as the agitation of the pulp within conduit 40 and cyclone 30, is accomplished in a single device of the present invention, corresponding to contactor 52. After discharging from contactor 52, the ozone/pulp reaction is substantially completed within porous bed reactor 54. The pulp bleaching system 50 of the present invention provides improved uniformity of pulp bleaching, in an economical manner, as compared to prior systems.

While the foregoing description has set forth a preferred embodiment of the invention in particular detail, it must be understood that numerous modifications, substitutions and changes can be undertaken without

departing from the true spirit and scope of the present invention as defined by the ensuing claims. For instance, although a cylindrical construction is preferred for the housing 62 of the substantially vertical pin/foil contactor 52, the contactor housing may alternatively comprise a varying tapered conical housing, as shown in co-pending and commonly assigned U.S. Patent Application having Serial No. 08/398,317, provided that a rotor is provided with a complimentary shape and the contactor remains substantially vertically disposed, as shown in U.S. Patent Application Serial No. 08/398,317. Additionally, although the apparatus and method of the present invention have been illustrated using ozone as the gaseous bleaching reagent, the apparatus and method of the present invention may be advantageously utilized in conjunction with gaseous bleaching reagents other than ozone, such as chlorine monoxide, chlorine dioxide, and others. However, it should be understood that the previously discussed pulp residence times of system 50 are intended to apply to the bleaching of high consistency wood pulp with ozone. The invention is therefore not limited to specific preferred embodiments as described, but is only limited as defined by the following claims.

WHAT IS CLAIMED IS:

1. A method for bleaching high consistency pulp with a gaseous bleaching reagent, said method comprising the steps of:

supplying a high consistency pulp to a first, upstream vessel **(52)**,

shredding the pulp within the upstream vessel **(52)** in the presence of a contacting gas including the gaseous bleaching reagent, a carrier gas, and reaction by-product gases 80 as to suspend the pulp in the contacting gas and to initiate reaction of the gaseous bleaching reagent with the pulp;

fluffing the shredded pulp within the upstream vessel **(52)**in the presence of the contacting gas so as to maintain the pulp in suspension in the contacting gas and to further react the gaseous bleaching reagent with the pulp, wherein said step of fluffing includes the steps of

creating a rotating annulus of fluidized particles of the shredded pulp within the upstream vessel **(52)**;

combing the rotating annulus of fluidized particles of the shredded pulp 80 as to further reduce the size of the shredded pulp particles and to fluff the pulp particles;

retaining the high consistency pulp within the upstream vessel **(52)** for a predetermined time which is sufficient to consume about 75% to about 90% of a selected dose of the gaseous bleaching reagent which is required to delignify the high consistency pulp from an initial Kappa number to an intermediate Kappa number; and

discharging the fluffed pulp and the contacting gas from the upstream vessel **(52)** to a second, downstream vessel **(54)** in which the reaction of the selected dose of the gaseous bleaching reagent with the pulp is substantially completed so as to further delignify the high consistency pulp from the intermediate Kappa number to a final Kappa number.

2. The method as recited in claim 1, further comprising the steps of:

inducing a countercurrent flow of the contacting gas relative to a flow of the pulp within the upstream vessel **(52)**;

flowing the contacting gas in co-current relationship with the pulp in the downstream vessel **(54)**.

3. The method as recited in claim 1, wherein said step of discharging includes the steps of:

separating the contacting gas from the pulp within a gas separation chamber of the upstream vessel **(52)**;

discharging the contacting gas from a gas outlet of the upstream vessel to a gas inlet of the downstream vessel **(54)**;

discharging the pulp from a pulp outlet of the upstream vessel **(52)** to a pulp inlet of the downstream vessel **(54)**.

4. The method as recited in claim 1, further comprising the steps of:

creating a bed of the fluffed pulp within the downstream vessel;

flowing the contacting gas through the bed of fluffed pulp so as to substantially complete the reaction of the selected dose of the gaseous bleaching reagent with the pulp.

5. The method as recited in claim 1, wherein:

the gaseous bleaching reagent is ozone; and

the predetermined time the pulp is retained within the upstream vessel **(52)** is sufficient to consume about 80% to about 90% of the selected dose of ozone and ranges from about 5 seconds to about 20 seconds.

6. The method as recited in claim 1, further comprising the step of:

flowing the high consistency pulp downward through the upstream vessel **(52)**.

7. A system for bleaching high consistency pulp with a gaseous bleaching reagent, said system comprising:

a substantially vertical pin/foil contactor having a gas inlet, a gas outlet, a pulp inlet, and a pulp outlet;

means for supplying high consistency pulp to said pulp inlet of said contactor **(52)**;

means for supplying fresh bleaching gas to said gas inlet **(72)** of said contactor **(52)**; and

a porous bed reactor having a gas inlet, a gas outlet, a pulp inlet, and a pulp outlet, wherein said gas inlet of said reactor is in fluid communication with said

gas outlet of said contactor and wherein said pulp inlet of said reactor communicates with said pulp outlet of said contactor; and

wherein said contactor further includes means for shredding the high consistency pulp supplied contactor and means for fluffing the shredded pulp.

8. The system as recited in claim 7, wherein:

said substantially vertical pin/foil contactor further includes a generally cylindrical housing communicating with said gas inlet and outlet, and said pulp inlet and outlet of said contactor;

said means for shredding the pulp comprises a shaft rotatably mounted within said housing, a drum attached to said shaft for rotation therewith, and a helically disposed screw flight attached to said drum and aligned with said pulp inlet of said contactor, wherein said screw flight includes a plurality of teeth-like surfaces disposed along an outer periphery of said screw flight.

9. The system as recited in claim 8, wherein:

said means for fluffing the shredded pulp comprises a plurality of pins attached to said drum and extending radially outwardly from said drum.

10. The system as recited in claim 8, wherein:

said means for fluffing comprises a means for creating a rotating annulus of fluidized particles of the shredded pulp and for combing the rotating annulus of fluidized pulp particles;

said rotating annulus of fluidized pulp particles is rotatable about an axially extending centerline axis of said pin/foil contactor.

11. The system as recited in claim 10, wherein:

said axially extending centerline axis is substantially vertical.

12. The system as recited in claim 10, wherein:

said housing of said pin/foil contactor includes an upper portion and a lower portion;

said creating and combing means comprises said drum, an inner wall of said lower portion of said housing, and a plurality of pins attached to said drum and extending radially outwardly from said drum.

13. The system as recited in claim 7, wherein:

said gas inlet of said pin/foil contactor is axially spaced from and vertically lower than said gas outlet of said pin/foil contactor;

said pulp inlet of said pin/foil contactor is axially spaced from and vertically higher than said pulp outlet of said pin/foil contactor.

14. The system as recited in claim 7, further comprising:

means for inducing a countercurrent flow of a contacting gas relative to a flow of said pulp within said contactor and for discharging the contacting gas from said contactor to said reactor, said means for inducing and discharging including a blower in fluid communication with

said gas outlet of said contactor and said gas inlet of said reactor.

15. The system as recited in claim 8, wherein:

said housing includes an upper portion and a lower portion;

said upper portion comprises a gas separation chamber.

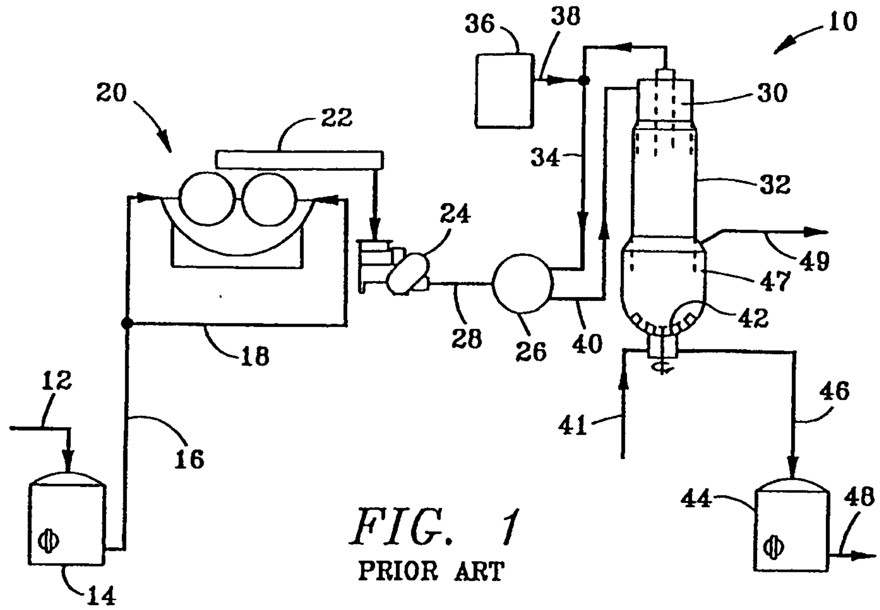


FIG. 1
PRIOR ART

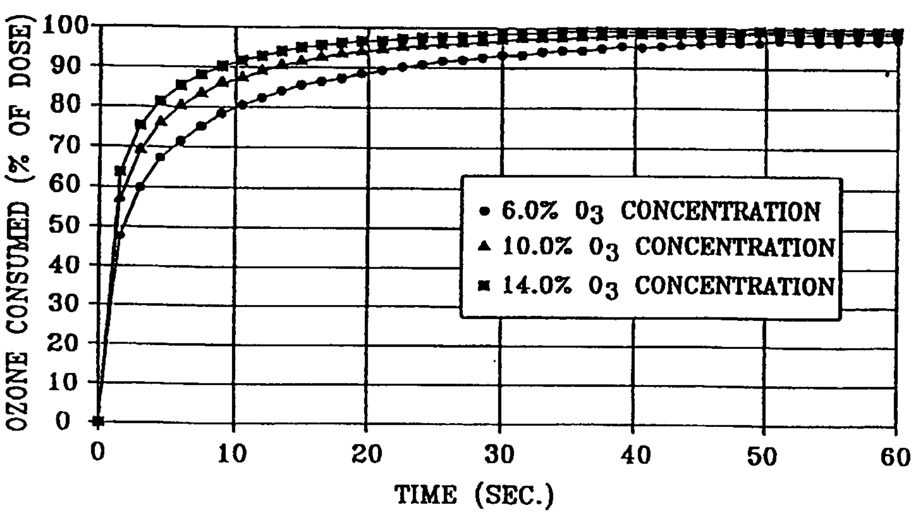


FIG. 2

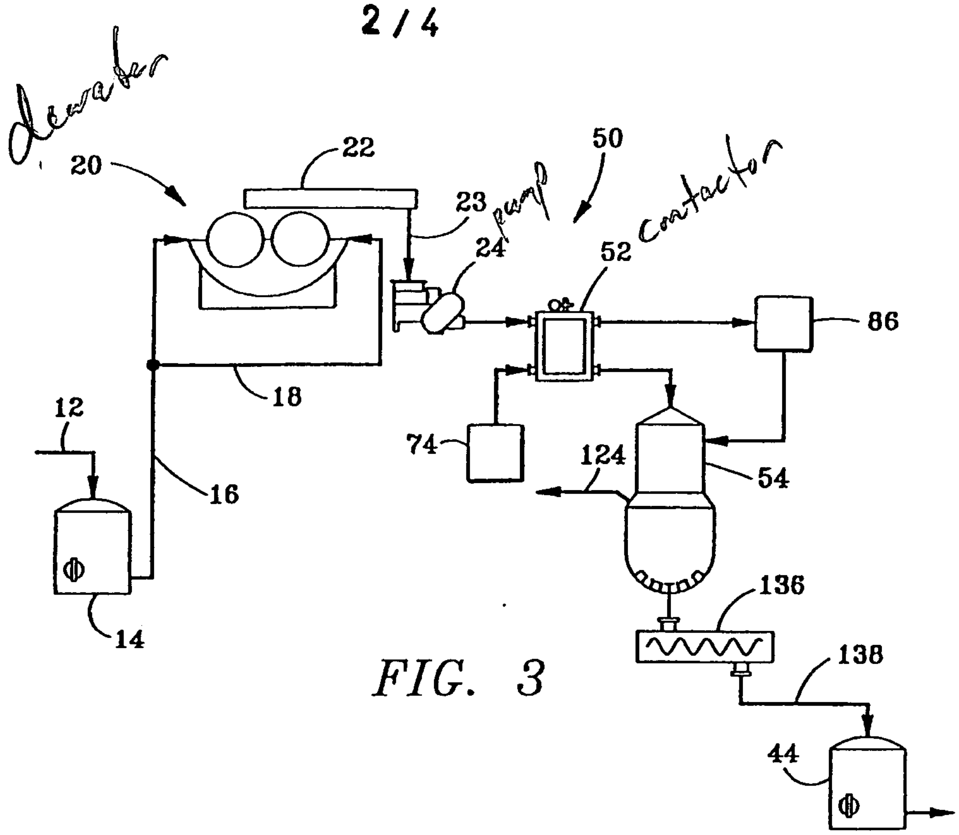

dewater
20
22
23
pump
24
50
52
contactor
86
18
12
74
124
54
16
136
14
138
44

FIG. 3

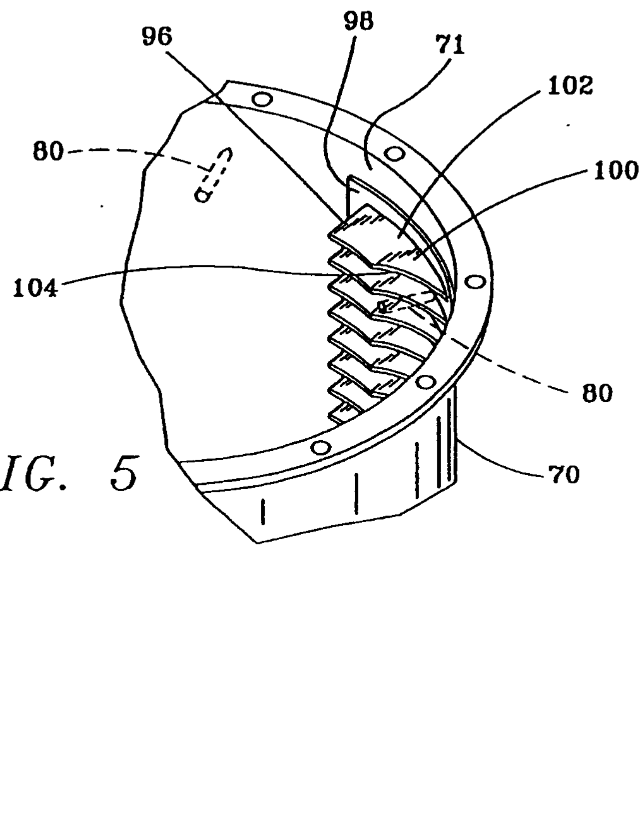
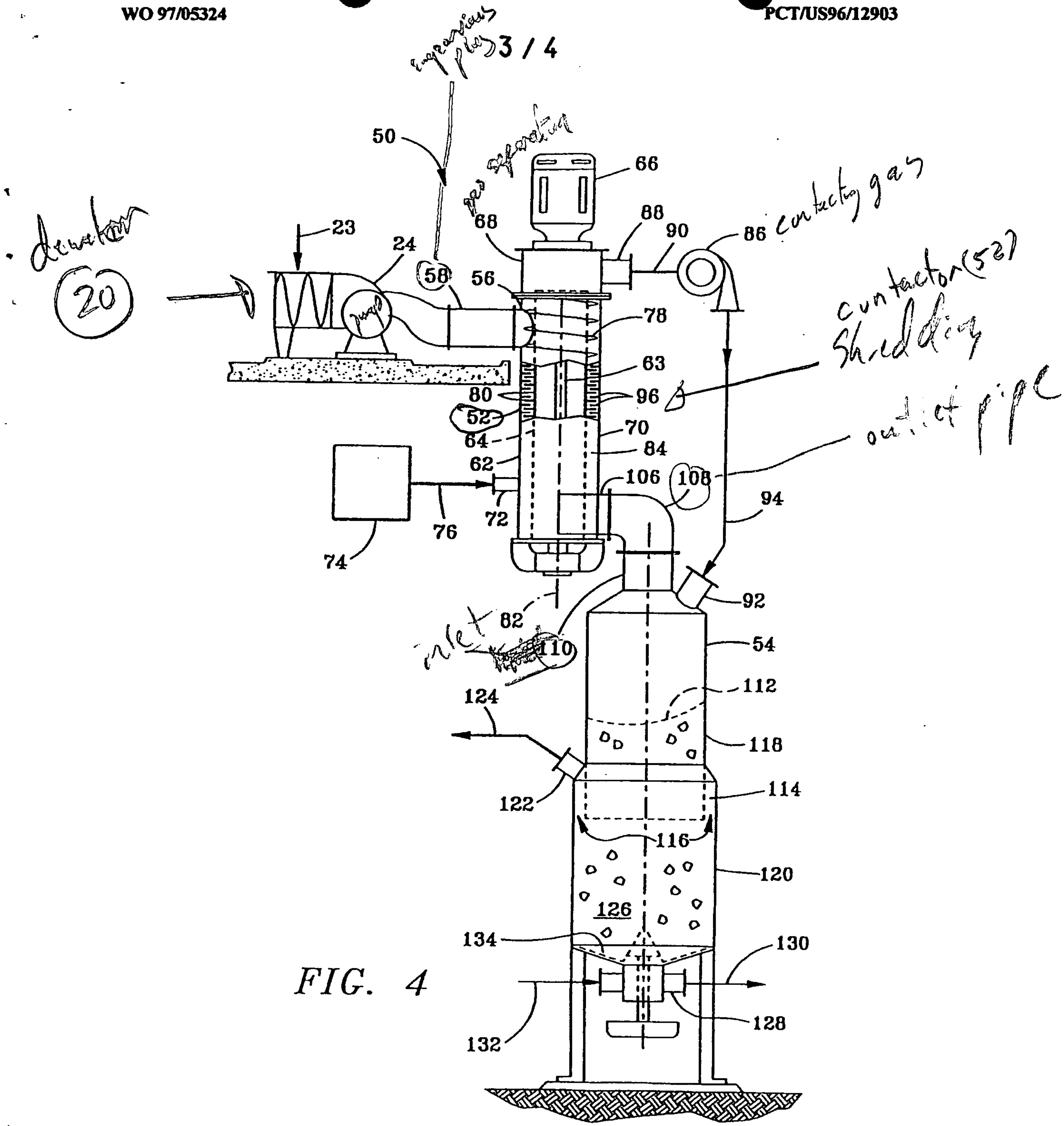

96
98
71
102
80
100
104
80
70

FIG. 5


expansions plug
50
gas separation
66
68
88
90
86 contacting gas
contactor (52)
Shedding
dewater
20
23
24
58
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56
78
63
80
96
52
64
70
84
outlet pipe
62
106
108
94
72
76
74
92
82
inlet
110
54
112
124
118
122
114
116
120
126
134
130
128
132

FIG. 4

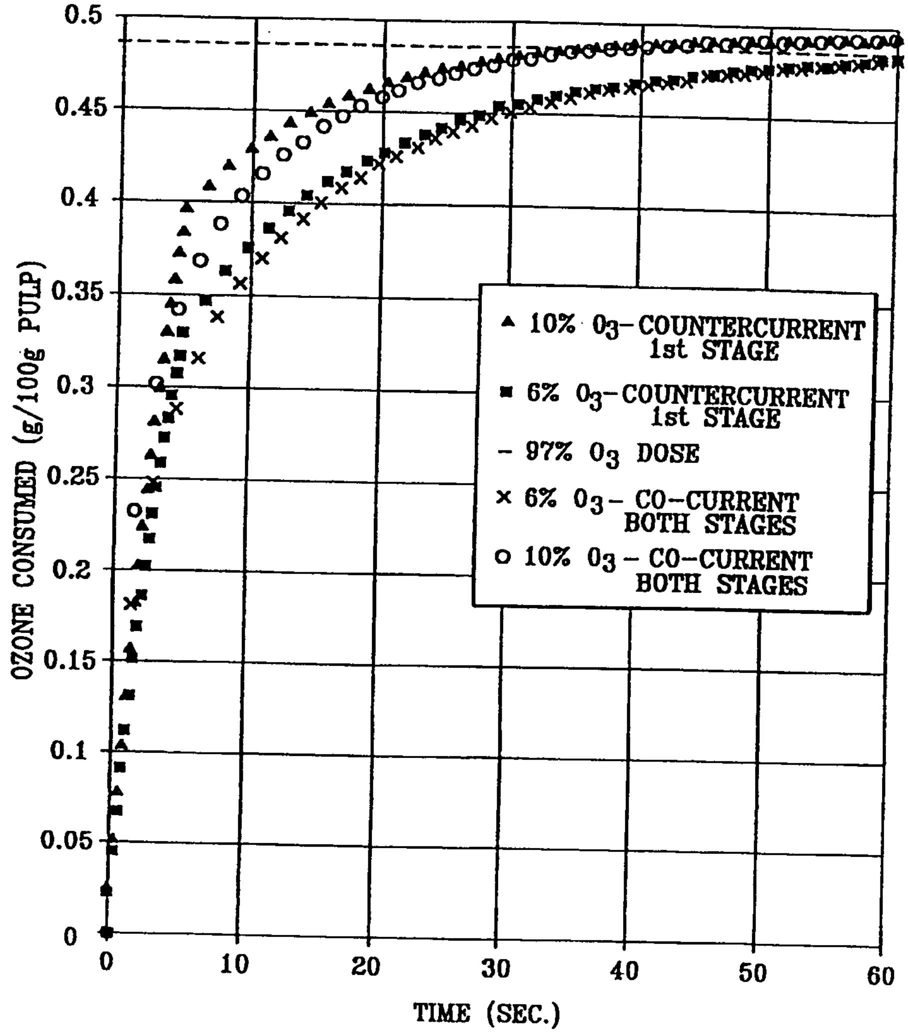
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
OZONE CONSUMED (g/100g PULP)
0
10
20
30
40
50
60
TIME (SEC.)
10% O3-COUNTERCURRENT 1st STAGE
6% O3-COUNTERCURRENT 1st STAGE
97% O3 DOSE
6% O3- CO-CURRENT BOTH STAGES
10% O3 - CO-CURRENT BOTH STAGES

FIG. 6

PATENT COOPERATION TREATY

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Date of mailing (day/month/year) 20 February 2001 (20.02.01)	
International application No. PCT/SE00/01052	**Applicant's or agent's file reference** LH/Ru 43402
International filing date (day/month/year) 24 May 2000 (24.05.00)	**Priority date** (day/month/year) 10 June 1999 (10.06.99)
Applicant BOKSTRÖM, Monica et al	

1. The designated Office is hereby notified of its election made:

   [X] in the demand filed with the International Preliminary Examining Authority on:

   03 January 2001 (03.01.01)

   [ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

   [ ] was not

   made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

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PUBLICATION NO. WO ____________

PUBLICATION DATE ____________

U. S. APPL. NO. 10/009052

INTERNATIONAL APPL. ____________

Application Filed By: 20 MOS. ______ 30 MOS. ______

Copy of International Application _____ Missing _____ Translation ____ Language ____________

WIPO Designated ________ Elected ________

Copy of Search Report (ISR)________

371 Filing fees ____paid _____insufficient

Total Claims _____ Chargeable _____ Independent _____ Multiple _____

Total Drawing Sheets __

Oath/Declaration ✓ missing _____ signed _✓_ unsigned _____ defective _____

Small entity _____ large entity ___

Biochemical Seq. Diskette _____ missing _____ damaged ____ entered ___ not entered ___

Biochemical Sequence listing ____missing ____ statement ____ no statement _____

Copy of References Cited in ISR _____

Copy of IPER_✓_

Annexes _____ entered _____not entered _____

Preliminary Amendments _✓_entered _____not entered

Information Disclosure Statement________

Request for Immediate Examination _____

Substitute Specification _____

Priority document______ RO/101 ______Assignment______ Other papers________

Extension of Time________

35 USC Receipt of Request ____________________

Date completion USC 371 Requirements ________

Notice of Missing Requirements ____________________

Notice of Defective ______ Response ______ Translation _____ Declaration

Notice of Acceptance ____________________

Notice of Abandonment ____________________

11 January 2002

METHOD AND SYSTEM FOR CONVEYING SHREDDED PULP TO AN OZONE REACTOR

The present invention relates to a method of treatment of pulp, which in a dewatering step is dewatered to a fibre concentration of at least 20% and which in a later bleaching step is bleached in an reactor vessel through reaction with ozone gas. The invention also relates to a system for treatment of pulp, comprising a dewatering device for dewatering the pulp to a fibre concentration of at least 20%, and a reactor vessel for bleaching the dewatered pulp through reaction with ozone gas.

In traditional systems for ozone bleaching of pulp at a high pulp concentration the pulp has to undergo a process comprising a number of preparatory treatment steps before the pulp finally can be bleached with ozone gas in the reactor vessel. Thus, the pulp is dewatered in an initial dewatering step in the dewatering device, usually in the form of a twin roll press. The dewatered pulp is shredded in a subsequent pulp shredding step in a shredder. The dewatered and shredded pulp is then transported in a transporting step, usually by a plug screw, from the shredder to a fluffer, in which the pulp is fluffed in a fluffing step. Once the pulp has undergone these preparatory steps it can be bleached in the reactor vessel.

The function of said plug screw is to compress the shredded pulp to a plug forming a gas lock preventing ozone gas from leaking from the reaction vessel upstream in the system to the surroundings. The function of the fluffer is to fluff up the compressed pulp leaving the pulp screw, so that the pulp gets a large specific surface, which facilitates the reaction of the ozone gas with the lignin of the pulp. Thus, the pulp entering the reactor vessel has to be fluffed, in order to obtain a high ozone utilisation and a good bleaching selectivity.

WO 9605365A1 shows a known pulp treatment system

comprising a pulp plug forming plugscrew for transportation of dewatered and shredded pulp to a fluffer, and a reaction vessel containing pulp bleaching gas.

Thus, the above described traditional pulp treatment system for bleaching pulp with ozone gas is relatively extensive and consequently expensive, which is a disadvantage. In addition, with several treatment steps in the process the entire system will be more sensitive to disturbances in each single part of the process. Therefore it would be of advantage if one or more treatment steps could be eliminated.

An object of the present invention is to provide a new method for treating pulp, which is bleached through reaction with ozone gas, which method is simpler and more reliable than traditional methods and results in an efficient ozone utilisation for the bleaching of the pulp.

This object is achieved by the method stated initially, which is characterised in that after the dewatering step and before the bleaching step the pulp is shredded in a closed pulp shredding vessel, the shredded pulp is transported without compression continuously out of the pulp shredding vessel through an outlet pipe therefrom, so that the outlet pipe is kept filled with passing pulp, from the outlet pipe of the pulp shredding vessel the shredded pulp is directly transported to the reaction vessel through a conduit which is gas sealed from the surroundings, the interior of the conduit communicating with the interior of the outlet pipe and with the interior of the reactor vessel, and the gas pressure in the pulp shredding vessel is kept higher than the gas pressure in the reactor vessel.

It has been proved that the combination of the two measures - (1) to keep the outlet pipe filled with passing shredded non- compressed pulp, and - (2) to maintain the gas pressure in the pulp shredding vessel higher than that of the

reactor vessel, is sufficient to prevent ozone gas from leaking upstream out to the surroundings. Hereby neither a plug screw nor a fluffer is needed, which makes the new method according to the invention particularly simple and reliable.

Advantageously the pressure difference between the gas pressure in the pulp shredding vessel and the gas pressure in the reactor vessel is regulated towards a predetermined value, wherein the gas pressures in the pulp shredding vessel and the reactor vessel are suitably kept under the surrounding atmospheric pressure.

Preferably, the shredded pulp is transported in the gas-tight conduit by the aid of gravity without need for any mechanical transportation means.

In the pulp shredding vessel the pulp is advantageously shredded by a transport screw with at least one toothed thread, wherein the transport screw also provides the transportation of the shredded pulp through the outlet pipe of the pulp shredding vessel.

A further object of the present invention is to provide a new system for treating pulp, which is bleached through reaction with ozone gas, which system is simpler than the above described traditional systems and eliminates the above mentioned disadvantages and problems thereof.

This object is obtained by the system stated initially, which is characterised by a pulp shredding device for shredding the dewatered pulp, which pulp shredding device comprises a closed pulp shredding vessel, an outlet pipe from the pulp shredding vessel, and a transport means for continuous transport of the shredded pulp without compressing the pulp out of the pulp shredding vessel via the outlet pipe, so that the latter is kept filled with passing pulp, a conduit which is gas sealed from the surroundings and which connects the outlet pipe of the pulp shredding vessel gas

tightly to the reaction vessel, so that the interior of the outlet pipe directly communicates with the reaction vessel via the interior of the conduit, and a pressure regulation device for maintaining a gas pressure in the pulp shredding vessel which is higher than that of the reaction vessel.

According to a preferred embodiment of the system according to the invention the transport means comprises a transport screw extending in the pulp shredding vessel, preferably also in the outlet pipe of the pulp shredding vessel, and which is provided with at least one toothed thread for shredding the pulp.

Advantageously the pressure regulation device regulates the pressure difference between the gas pressure in the pulp shredding vessel and the gas pressure in the reactor vessel toward a predetermined value.

Preferably the pressure regulation device comprises a first fan with a controllable capacity arranged in a gas outlet in the pulp shredding vessel for evacuation of gas therefrom, a second fan with controllable capacity arranged in a gas outlet in the reactor vessel for evacuation of gas therefrom, a first pressure sensor for sensing the gas pressure in the pulp shredding vessel, a second pressure sensor for sensing a gas pressure in the reaction vessel, and a regulation unit which in response to the first and second pressure sensors, respectively, regulates the capacity of the first and second fans, respectively.

The invention is described in more detail in the following with reference to the accompanying drawing, in which figure 1 schematically shows an example of the system according to the present invention, and figure 2 and 3, respectively, is a cross section along the line II-II and III-III, respectively, in figure 1.

The drawing shows a system for treatment of pulp comprising a dewatering device 2, a pulp shredding device 4

and a reaction vessel 6 for bleaching of pulp through reaction with ozone gas. The dewatering device 2 comprises two pressure rolls 8, which are arranged to counter rotate in a housing 10, and an inlet 12 for pulp to be dewatered in the lower part of the housing 10. A motor 14 provides for the rotation of the pressure rolls 8. An elongated closed pulp shredding vessel 16 extends along the pressure rolls 8 above these. In the pulp shredding vessel 16 a transport screw 18 extends in parallel with the pressure rolls 8. Another motor 20 is adapted to rotate the transport screw 18. The pulp shredding vessel 16 has a lower elongated inlet for pulp to be dewatered by the pressure rolls 8, see figure 2 and an outlet pipe 22, through which the transport screw 18 extends in part, for dewatered and shredded pulp.

The transport screw 18 has a core 24 with a constant diameter and a toothed transport thread 26 with a constant pitch and diameter. The portion of the transport thread 26 extending in the outlet pipe 22 may alternatively be non-toothed. The interior of the outlet pipe 22 also has a constant diameter which is somewhat larger than the diameter of the transport thread 26. Alternatively the transport screw 18 may have more than one transport thread 26.

A vertical gas-tight conduit 28 connects the outlet pipe 22 gas-tightly to an upper inlet 30 in the reaction vessel 6, so that the interior of the outlet pipe 22 directly communicates with the interior of the reaction vessel 6 via the interior of the conduit 28. The reaction vessel 6 has a lower outlet conduit 32 provided with a valve 34, for discharge of bleached pulp, and an upper outlet conduit 36 for evacuation of gas. There is also a device, not shown, for supplying ozone gas to the interior of the reaction vessel 6.

A regulation unit 38 is by means of signal lines connected to a pressure sensor 40 for sensing the gas pressure P1 in the pulp shredding vessel 16 and to a pressure

sensor 42 for sensing the gas pressure P2 in the reaction vessel 6. The regulation unit 38 is by means of further signal lines also connected to a fan 44 with a controllable capacity located in an upper outlet conduit 46 from the pulp shredding vessel 16, and to another fan 48 likewise with a controllable capacity located in the upper outlet conduit 36 of the reaction vessel 6.

During operation a pulp suspension is pumped through the inlet 12 of the dewatering device 2 to the pressure rolls 8, which are counter rotated by the motor 14, the direction of rotation of the pressure rolls being indicated by arrows in figure 3, so that the pulp is pulled between the pressure rolls 8 while being dewatered up to the inlet of the pulp shredding vessel 16. When entering the inlet of the pulp shredding vessel 16 the dewatered pulp has a fibre concentration of 20-45%. In the pulp shredding vessel 16 the pulp is shredded by the toothed transport thread 26 of the transport screw 18, which is rotated by the motor 20. Depending on the desired result the toothing of the transport thread 26 may be shaped so that a relatively coarse or fine shredding of the pulp is obtained. In addition the transport screw 18 transports shredded pulp through the outlet pipe 22 without compressing the pulp. From the outlet pipe 22 the shredded pulp drops through the vertical conduit 28 to the reaction vessel 6, where the pulp is bleached through reaction with ozone gas. Finally the bleached pulp is discharged from the reactor vessel 6 through the lower outlet conduit 32.

The regulation unit 38 controls the capacity of the fans 44 and 48, for instance by speed control, in response to the pressure sensors 40 and 42, so that the gas pressure P1 in the pulp shredding vessel 16 is kept higher than the gas pressure P2 in the reaction vessel 6. At least the gas pressure P2 is kept by the regulation unit 38 below the

surrounding atmospheric pressure. Suitably the regulation unit 38 keeps the gas pressure P1 in the range of 0-14 kPa (overpressure) and the gas pressure P2 in the range 1-15 kPa (overpressure) at the same time as the regulation unit 38 regulates the pressure difference between the gas pressures P1 and P2 towards a predetermined value, which is chosen in the range of 0,5-1,5 kPa.

By the fact that the shredded and fluffed pulp transported by the transport screw 18 through the outlet pipe 22 completely fills the latter at the same time as the gas pressure is decreased from the interior of the pulp shredding vessel to the interior reactor vessel, ozone gas is efficiently prevented from passing upstream in the system to the surroundings.

CLAIMS

1. A method of treating of pulp, which in a dewatering step is dewatered to a fibre concentration of at least 20% and which in a later bleaching step is bleached in a reaction vessel (6) through reaction with ozone gas, **characterised in** that

- after the dewatering step and before the bleaching step the pulp is shredded in a closed pulp shredding vessel (16),
- the shredded pulp is transported without compression continuously out of the pulp shredding vessel through an outlet pipe (22) therefrom, so that the outlet pipe is kept completely filled with passing pulp,
- from the outlet pipe of the pulp shredding vessel the shredded pulp is directly transported to the reactor vessel (6) through a gas-tight conduit (28) which is gas sealed from the surroundings, the interior of the conduit communicating with the interior of the outlet pipe and with the interior of the reaction vessel, and
- the gas pressure (P1) in the pulp shredding vessel is kept higher than the gas pressure (P2) in the reaction vessel.

2. A method according to claim 1, **characterised in** that the pressure difference between the gas pressure (P1) in the pulp shredding vessel (16) and the gas pressure (P2) in the reaction vessel (6) is regulated towards a predetermined value.

3. A method according to claim 2, **characterised in** that the gas pressures (P1, P2) in the pulp shredding vessel (16) and the reaction vessel (6) are kept below the surrounding atmospheric pressure.

4. A method according to any of claims 1-3, **characterised in** that the shredded pulp is transported by gravity in the gas-tight conduit (28).

5. A method according to any of claims 1-4, **characterised in** that in the pulp shredding vessel (16) the pulp is shredded by a transport screw (18) with at least one toothed transport thread (26), the transport screw also providing a transport of the shredded pulp through the outlet pipe (22) of the pulp shredding vessel.

6. A system for treatment of pulp, comprising a dewatering device (2) for dewatering the pulp to a fibre concentration of at least 20%, and a reaction vessel (6) for bleaching the dewatered pulp through reaction with ozone gas, **characterised by** a pulp shredding device (4) for shredding the dewatered pulp, which pulp shredding device comprises a closed pulp shredding vessel (16), an outlet pipe (22) from the pulp shredding vessel, and a transport means (18) for continuous transport of the shredded pulp without compressing the pulp out of the pulp shredding vessel via the outlet pipe, so that the latter is kept filled with passing pulp, a conduit (28) which is gas sealed from the surroundings and connects the outlet pipe of the pulp shredding vessel gas-tightly to the reaction vessel, so that the interior of the outlet pipe directly communicates with the interior of the reaction vessel through the interior of the conduit, and a pressure regulation device (38, 40, 42, 44, 48) for maintaining a gas pressure (P1) in the pulp shredding vessel which is higher than the gas pressure (P2) in the reaction vessel.

7. A system for treatment of pulp according to claim 6, **characterised in** that the transport means comprises a transport screw (18) extending in the pulp shredding vessel

(16) and provided with at least one toothed transport thread (26) for shredding the pulp.

8. A system for treatment of pulp according to claim 7, **characterised in** that the transport screw (18) also extends in the outlet pipe (22) of the pulp shredding vessel (16).

9. A system for treatment of pulp according to any of claims 6-8, **characterised in** that the pressure regulation device (38, 40, 42, 44, 48) regulates the pressure difference between the gas pressure (P1) in the pulp shredding vessel (16) and the gas pressure (P2) in the reaction vessel (6) towards a predetermined value.

10. A system for treatment of pulp according to claim 9, **characterised in** that the pressure regulation device (38, 40, 42, 44, 48) comprises a first fan (44) with controllable capacity arranged in a gas outlet (46) in the pulp shredding vessel (16) for evacuation of gas therefrom, a second fan (48) with controllable capacity arranged in a gas outlet (36) in the reaction vessel (6) for evacuation of gas therefrom, a first pressure sensor (40) for sensing the gas pressure (P1) in the pulp shredding vessel (16), a second pressure sensor (42) for sensing the gas pressure (P2) in the reaction vessel (6), and a regulation unit (38) which in response to the first and second pressure sensors, respectively, regulates the capacity of the first and second fans, respectively.

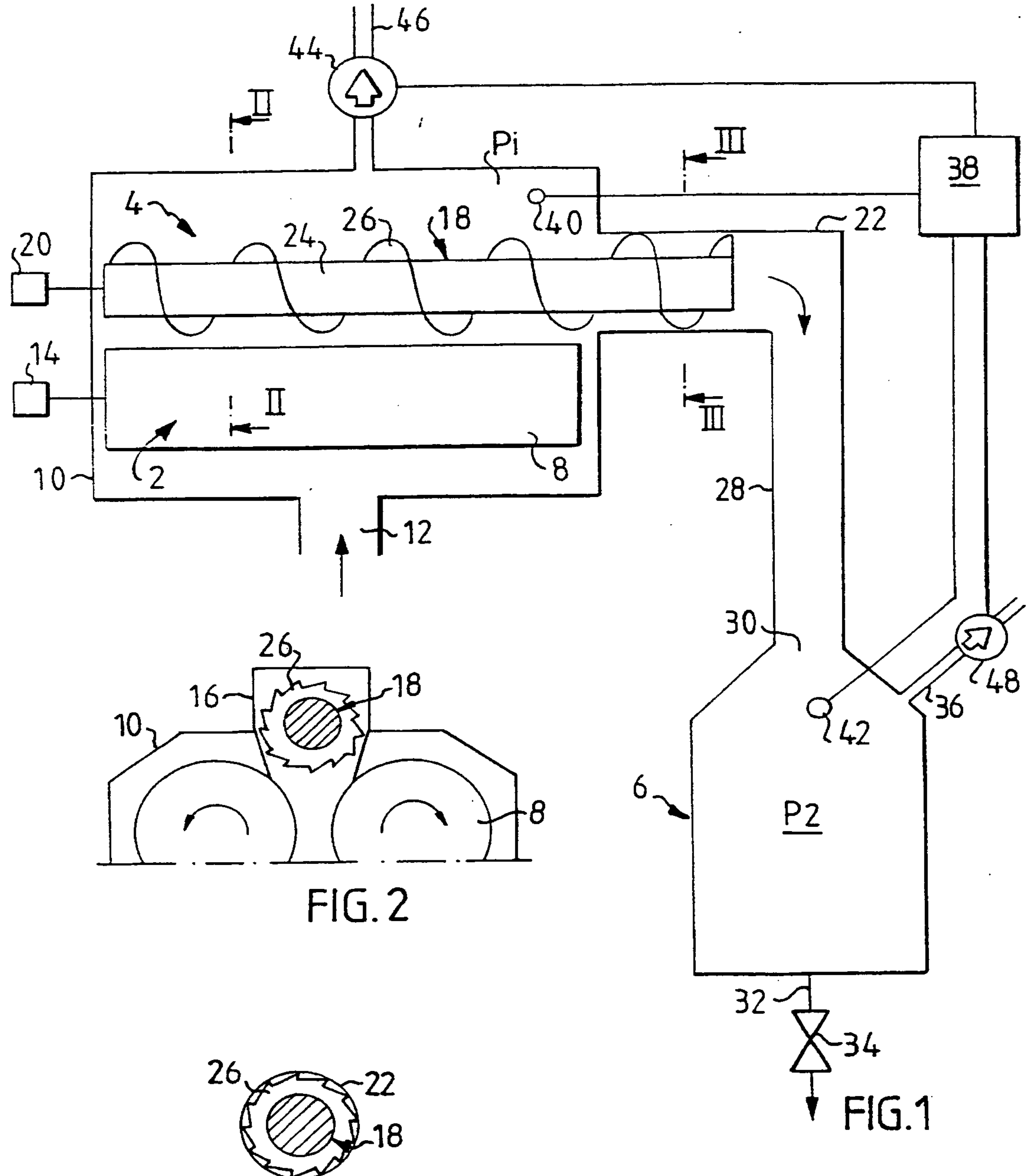

FIG.1

FIG.2

FIG.3